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THE MINE DRAINAGE STUDY

North Branch Potomac River Basin

PHASE I

BASELINE SURVEY

BALTIMORE DISTRICT • CORPS OF ENGINEERS

MAY 1977

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NORTH BRANCH POTOMAC RIVER BASIN MINE DRAINAGE STUDY.

PHASE I. BASELINE SURVEY.

9 FINAL REPORT.

SUBMITTED TO:

BALTIMORE DISTRICT
CORPS OF ENGINEERS

11 6 MAY 1977

12 284p.

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409 111

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) North Branch Potomac River Basin Study Mine Drainage Study - Phase I Baseline Survey		5. TYPE OF REPORT & PERIOD COVERED Final Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Skelly & Loy Engineer Consultants 2601 North Front Street, Harrisburg, PA 17110		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Baltimore District Corps of Engineers P.O. Box 1715, Baltimore, MD 21203		12. REPORT DATE May 1977
		13. NUMBER OF PAGES 295
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Acid mine drainage, abatement, reclamation, surface mining, underground mining, water quality, pH, net alkalinity, simulation model, plan formulation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This baseline survey of the mine drainage and related water resources of the North Branch Potomac River Basin established the extent, magnitude, and effects of coal mine drainage pollution. Alternative abatement and reclamation solutions were considered. Study included an analysis of socio-economic and environmental conditions as related to the mine drainage problem.

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CONCLUSIONS

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CONCLUSIONS

- There are 15 coal seams - all of Pennsylvania Age - in the basin that have at some time been mined.
- Hydrologic conditions within the coal-bearing portions of the basin have been altered significantly by extensive surface and underground mining.
- Strata underlying the study area comprise three general hydrologic units; the unit containing the most productive aquifers lies totally outside the coal field.
- A substantial portion of the mine drainage pollution degrading West Virginia tributaries to the North Branch Potomac River is associated with recent, but not active, mining activities.
- Active mining operations, formerly major polluters of the North Branch Potomac River, have implemented acceptable mine drainage treatment programs, substantially reducing their degradational impacts on the river.
- North Branch Potomac River tributaries on the Maryland side of the basin are primarily degraded by abandoned mine discharges.
- The North Branch Potomac River Basin computer simulation model previously developed for the Corps has been updated with current data to simulate three distinct base situations:

  1) Confirmed 1976 Base Conditions.
  2) Projected 1977 Base Conditions - projecting impacts of on-going active mine discharge clean-up efforts and a Maryland DNR mine drainage abatement demonstration project.
  3) Projected 1977 Base Conditions with Bloomington Lake - incorporating a Bloomington Lake model into the previous simulation.

- Water quality in the North Branch Potomac River has significantly improved in recent years; major improvements were noted even during the brief life of this study.

- Westvaco has taken great strides in efforts to improve the quality of their effluents, now discharging from the Upper Potomac River Basin Commission Sewage Treatment Plant at Westernport, Maryland.

- Despite noted reductions in both acid mine drainage above Westvaco and industrial effluent below Westvaco; the net alkalinity of the river below Westvaco has steadily dropped, as the effluent which formerly neutralized the acid mine drainage is cleaned-up by government mandate.

- Active mining operations should pose little or no threat of serious pollution, since their discharges must be in compliance with fairly stringent State and Federal effluent guidelines and mine reclamation or closure regulations.

- Aerial photographs and overlays at 1:24,000 scale, as well as task report appendices, developed during the course of this study, contain a wealth of information on the basin's active and abandoned surface mines, underground mine surface facilities, and coal outcrops.

- Surface mining and lumbering throughout the basin have had the principal deleterious effects upon the natural terrestrial ecosystem.

- Forest lands cover nearly 70% of the North Branch Potomac Basin.

- There are no wildlife species within the project area listed on the national register as being endangered, although seven species have been classified by Maryland DNR as being "threatened with statewide extinction".

- Evidence of a healthy aquatic ecosystem is not observed in the North Branch Potomac River above Oldtown, Maryland.

- Population in the study area has remained relatively stable since 1960.

- The economic base of the study area is composed of mining, agriculture, manufacturing, and tourism.

- Within the study area, the greatest opportunity for income growth is in the mining sector; several new mines are in development stages

even as this report is printed.

- According to a prominent Appalachian planner and economist, "On balance, the Upper Potomac River Basin probably has a more promising future than many other regions of the nation. ... But the combination of good location, resource base, and improving transportation facilities support the projection of slow but steady progress in the Basin for the rest of this century".

- Population and employment projections to year 2020 based on OBERS, Maryland State Planning data, and information generated in this study show significant growth in Garrett and Grant Counties, stable conditions in Mineral County, and declines in Allegany County.

- Future water quality within the basin is expected to approximate that shown in the Projected Base Conditions with Bloomington Lake, unless subsequent Phase II abatement activities yield water quality improvements.

- Total coal production and surface mine coal production, and underground mine coal production are all expected to increase in future years.

- Three types of land use were assumed to result from surface mine reclamation: urban, agricultural, and forest.

- The following dollar values were developed to quantify land-oriented benefits of surface mine reclamation:

  1) Hunting - $17.60/Acre/Year
  2) Aesthetics/Recreation - $12.30/Acre/Year
  3) Timber Production - $5.00/Acre/Year
  4) Agriculture - $100.00/Acre/Year
  5) Employment - 30% of Annual Reclamation Cost (over 30 years)
  6) Land Values - $50.00/Acre/Year

- The following dollar values were developed to quantify water-oriented benefits of reclamation and abatement:

1) Fishing – $4,570/Year/Stream Mile raised to pH=6.0
2) Non-Fishing Stream Recreation – $450/Year/Stream Mile raised to pH=5.0
3) Water Treatment Cost Savings – $5.00/Million Gallons Treated

- Abatement Alternative NBP-7A, which includes watersheds 5, 18, 19, 20, 26, 27, 28, 29, 31, and 32 along the North Branch Potomac, yields a pH of 6.0 in proposed Bloomington Lake and in the river's entire main stem above the proposed lake.

- None of the Georges Creek Abatement Alternatives had significant downstream water quality impacts, since 1) only the lowermost reaches of that stream fall below pH 6.0; and 2) water quality in the North Branch Potomac River below the mouth of Georges Creek is almost totally dominated by the sewage treatment plant discharge.

RECOMMENDATIONS

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RECOMMENDATIONS

- The primary recommendation resulting from this Phase I planning study is the immediate initiation of Phase II detailed reclamation and abatement feasibility investigations in several Priority I watersheds.

- It is recommended that, as funds become available, the Corps continue their efforts in individual high priority watersheds.

- Contingent on available funding, it is recommended that West Virginia and Maryland also initiate detailed feasibility investigations on their own initiative.

- It must be realized that, although Abatement Alternative projections assumed 100% abatement of acid mine drainage within each watershed, Phase II studies may reveal that it is not technologically possible to achieve this objective in some watersheds. Thus, it is imperative that Phase II studies be initiated, not only in the Priority I watersheds, but also in the somewhat lower ranked Priority II areas.

- Activities in high priority watersheds should not cease with completion of Phase II studies; there should be a follow-up effort in terms of actual reclamation and abatement activities.

- There should be a concerted effort during Phase II studies to locate sources of state and federal funding assistance for subsequent recommended reclamation and abatement activities. This search should extend beyond the typical reclamation and abatement funding agencies. Novel uses of reclaimed lands could lead to funding sources not normally associated with these activities.

- A stream monitoring program - discussed in detail in the Task 2 Report - should be established and maintained, perhaps with the joint financial cooperation of various state and federal agencies. This program will be particularly important in assessing impacts of Phase II reclamation and abatement activities in individual watersheds. If funding is not available to maintain a basin-wide monitoring program, it is still recommended that reclamation

and abatement activities in individual watersheds be monitored. Although both chemical and biological monitoring are desirable, it is felt that the chemical parameters are more critical, and should be monitored even if biological monitoring cannot be funded.

INTRODUCTION AND SUMMARY

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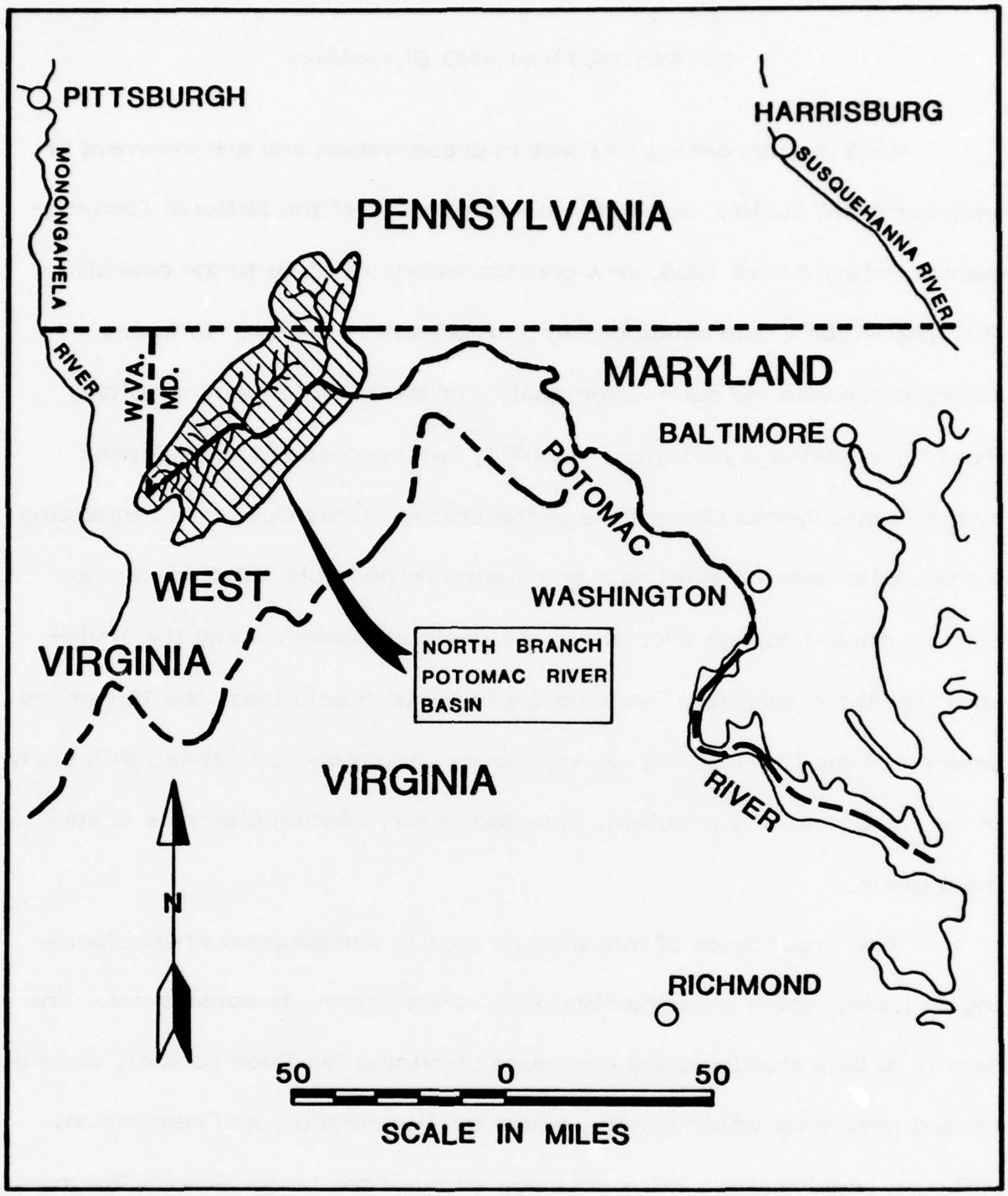
INTRODUCTION AND SUMMARY

With the increasing interest in preservation and enhancement of environmental quality, as evidenced by passage of the National Environmental Policy Act of 1969, new considerations relative to the overall Potomac River Basin development plan began to emerge. Primary among these was the poor water quality of the North Branch resulting from mine drainage pollution. In 1971, two resolutions were passed by the Public Works Committee of the United States Congress requesting a study with specific emphasis on developing possible solutions to the critical mine drainage problem in the basin and determining the advisability of their adoption. Subsequent to these resolutions, the Baltimore District of the United States Army Corps of Engineers initiated this study of the mine drainage problem, directed at formulating alternate abatement plans.

The importance of this study's goal is compounded when Bloomington Lake, which is currently under construction, is considered. The dam is to be a multipurpose structure providing for flood control, domestic and industrial water supply, water quality control, and recreation. Although specifically a mine drainage study of the North Branch Potomac River Basin, this study has generated important information on the compatibility of Bloomington Lake's proposed uses with the existing water quality.



VICINITY MAP
NORTH BRANCH
POTOMAC RIVER BASIN

FIGURE 1

In October of 1973, the Water Resources Council (WRC) established "Principles and Standards for Planning Water and Related Land Resources" (P&S) which give direction to planning efforts at all Federal levels, and assist in the preparation and evaluation of resource management programs. Plans for the use of the Nation's water and land resources are to be directed toward improvement of the quality of life through contributions to the objectives of national economic development (NED) and environmental quality (EQ). The beneficial and adverse effects of alternate plans on these objectives are to be displayed during the planning process so that the best programs for resource management may be selected for implementation.

The Corps of Engineers, as one of the Nation's primary resource management agencies, has responded to recent environmental and economic policy legislation by establishing guidelines by which this policy is to be implemented. In recognition of the necessity to equally consider social, economic, and environmental aspects of a proposed resource management program, a series of Engineer Regulations (ER's) has been developed to outline the planning process which will be utilized for developing alternate plans. These ER's are listed below:

- ER 1105-2-200 "Planning Process: Multiobjective Planning Framework"

- ER 1105-2-210 "Planning Process: Plan Development Stages"
- ER 1105-2-220 "Planning Process: Problem Identification (Task 1)"
- ER 1105-2-230 "Planning Process: Formulation of Alternatives (Task 2)"
- ER 1105-2-240 "Planning Process: Impact Assessment (Task 3)"
- ER 1105-2-250 "Planning Process: Evaluation (Task 4)"
- ER 1105-2-921 "Feasibility Reports: System of Accounts"

The planning process is a systematic approach to analyzing publicly expressed problems, establishing planning objectives and developing and evaluating alternate resource management actions. Requiring the performance of a number of interrelated tasks and activities, it provides the information necessary to enable an effective choice among the alternatives presented.

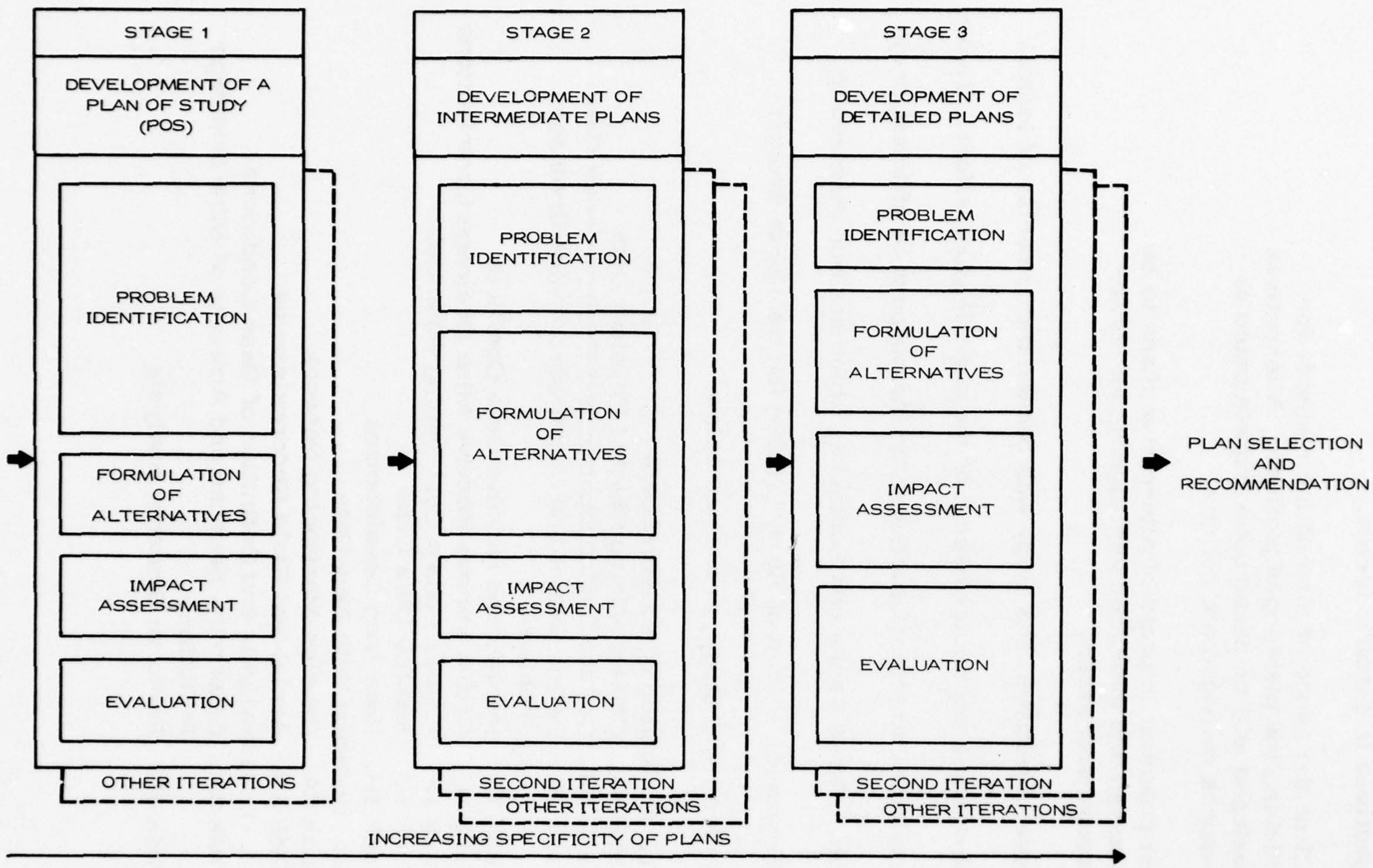
The process involves three stages of plan development with increasing detail and analysis throughout each stage. The stages, which are shown in Figure 2, are identified as:

<u>Stage I</u> - Development of Plan of Study

<u>Stage II</u> - Development of Intermediate Plans

<u>Stage III</u> - Development of Detailed Plans

Current project efforts fell within the realm of Stage II, and were aimed at achievement of the following goals:



GENERAL RELATIONSHIP OF PLAN DEVELOPMENT STAGES AND FUNCTIONAL PLANNING TASKS

FIGURE 2

FROM: ER 1105-2-200

1. Problem identification and definition of planning objectives in specific terms.

2. Outline the range of alternative methods for achieving the planning objectives. Alternatives developed will be based upon and evaluated as resource management options.

3. List potential impacts of alternative plans to be assessed and evaluated with significant consequences addressed.

To achieve these objectives, the study was broken into a series of logical tasks, each aimed at a particular aspect of the overall study effort. Tasks in turn were divided into logical subtasks for the purpose of efficient project prosecution. These Tasks and Subtasks, which are summarized in the Corps of Engineers' "Plan of Study" (POS) for the North Branch Potomac Mine Drainage Study, are listed below:

- Task 1. Collection of Existing Data
  - Task 1A. Collect Mining Related Physical Data
  - Task 1B. Collect Socioeconomic and Environmental Data
  - Task 1C. Define Extent and Magnitude of Mine Drainage Problem
  - Task 1D. Identify and Resolve Data Conflicts
  - Task 1E. Active Versus Inactive Mine Drainage Contributions
  - Task 1F. Assess Future Coal Mining Potentials
  - Task 1G. Identify Data Gaps
  - Task 1H. Base Map Development
- Task 2. Updating With New Data
  - Task 2A. Develop Monitoring Network
  - Task 2B. Aerial and Field Reconnaissance
- Task 3. Data Analysis and Definition of Base Conditions
  - Task 3A. Determine Sources and Amounts of Mine Drainage Pollution
  - Task 3B. Perform Systems Analysis

Task 3C. Describe Base Conditions
Task 3D. Project Future Conditions
Task 4. Formulation
Task 4A. Establish Range of Abatement Measures
Task 4B. Relate Measures to Objectives
Task 4C. Develop Abatement Alternatives and Plans
Task 4D. Display Impacts of Plan
Task 5. Sub-basin Priorities
Task 5A. Develop Sub-basin Priorities
Task 5B. Final Report

The following paragraphs briefly summarize the primary activities in each of these five tasks.

The initial study tasks defined existing conditions and produced baseline projections (future do-nothing conditions) on the basis of these conditions. Tasks 1 and 2 detailed environmental, socioeconomic, and mining data for the study area. Since these tasks both addressed problem identification, they were very closely related and actually complemented one another in a number of areas. In Task 1, problems associated with acid mine drainage were initially identified and an extensive data base was established. All available data pertaining to water quality, geology, mining history, current mining, coal reserves, climatology, socioeconomics, and general environmental information were collected. The water quality data generated in this task enabled a preliminary analysis of the extent and magnitude of mine drainage within the North Branch Potomac River Basin. This, in turn, permitted delineation of six major

stream basins and 80 working watershed units within the study area. Existing water quality data also provided valuable insight into the question of relative mine drainage contributions of active versus abandoned operations. Geologic and mining history information was gathered and compiled for presentation in Task 2. This information, in conjunction with current mining and coal reserve data, was utilized to predict future mining trends within the basin.

Data gaps were defined in Task 1, so that Task 2 data gathering efforts could be concentrated to fill those gaps. Throughout Task 1, the pertinent data were plotted on both 1:125,000 scale base maps and working copies of USGS 7.5 Minute Topographic Quadrangles. These maps were continually updated as new information became available.

The stream sampling and aerial and field reconnaissance conducted in Task 2 aided in dealing with active versus inactive mine drainage contributions. Also base map development was significantly improved through the aerial and field reconnaissance program. The Task 2 contributions in updating the data base generated three products: detailed water quality evaluations, future monitoring recommendations, and detailed base mapping.

Task 3 utilized the data generated in Tasks 1 and 2 to produce an assessment or profile of base conditions and a prediction of future conditions

within the North Branch Potomac River Basin assuming no acid mine drainage abatement activities. The base conditions defined in this task included the following parameters:

- Surface water quality
- Geography
- Geology
- Hydrology
- Climatology
- Air quality
- Mining
- Ecology
- Socioeconomics

The projections of baseline conditions relied on sophisticated modeling techniques for both the environmental and socioeconomic parameters. A systems analysis approach was applied to produce water quality projections upon which many of the environmental projections were based. Multiple regression techniques were applied to an economic base model to produce the socioeconomic projections. These highly technical approaches allowed for the maximum use of the data base to produce detailed future projections with a high degree of reliability.

The objective of Task 4 was to formulate specific plans to abate acid mine drainage and to assess their impacts. This task followed the logical progression of identifying specific problems, building detailed abatement plans to attack those problems, and assessing the impacts of the plans in terms of costs and benefits. Initially in Task 4, a wide

range of abatement measures and techniques described in the EPA manual, "Processes, Procedures, and Methods to Reduce Pollution from Mining Activities" (October, 1973), are assessed for potential use in each plan. Measures in addition to those traditionally associated with acid mine drainage abatement were also considered.

Abatement measures were then evaluated with respect to planning objectives. Primary emphasis was given to National Economic Development (NED) and Environmental Quality (EQ) objectives with particular emphasis on water quality impacts, recreational opportunities, fish and wildlife, and general ecosystem impacts.

Plans were formulated by synthesizing the different abatement measures into resource management systems which satisfy national and local planning objectives. Alternatives established outlined extremes in the range of plans — basin-wide abatement plans were compared with plans which isolated particular sub-watershed groupings. Also, land improvement plans were compared with water quality improvement plans. Impacts for each plan were displayed showing cost-effectiveness, land-oriented benefits, and water-oriented benefits. A complete environmental/socioeconomic assessment was conducted and impacts defined. All impacts were then evaluated as they related to NED and EQ objectives.

Finally, in Task 5, an objective ranking process was implemented and utilized to select the top ranking abatement alternative and to establish individual watershed reclamation and abatement priorities. Based largely on the data generated in Task 4, each study area watershed was placed in a priority category. The top ranking abatement alternative was determined to be NBP-7A, and the watersheds included in that alternative were subsequently placed in the highest priority category. A scheme was also developed to enable priority action of the remaining watersheds in the Upper North Branch Potomac River, Savage River, Georges Creek, and Wills Creek Basins. Table 1 presents a summary of those watershed priority assignments and Tables 7, 8, 9, and 10, beginning on page 150, summarize the estimated costs of reclamation and abatement in those watersheds.

Table 1

SUMMARY
FINAL WATERSHED PRIORITY RANKING

PRIORITY I

UNB-5	UNB-20	UNB-29
UNB-18	UNB-23	UNB-31
UNB-19	UNB-26	UNB-32
	UNB-27	
	UNB-28	

PRIORITY II

UNB-15	UNB-39	GC-14
UNB-24	UNB-40	GC-15
UNB-25	SR-3	GC-16
UNB-35	GC-6	GC-17
UNB-36	GC-12	WC-15
	GC-13	WC-16

PRIORITY III

UNB-1	UNB-14	GC-2
UNB-2	UNB-16	GC-3
UNB-3	UNB-21	GC-4
UNB-4	UNB-33	GC-5
UNB-6	UNB-38	GC-9
UNB-10	SR-2	WC-17
UNB-11	GC-1	WC-19
UNB-13		WC-20

Table 1 (Continued)

PRIORITY IV

UNB-7	UNB-22	GC-10
UNB-8	UNB-30	GC-11
UNB-9	UNB-34	WC-11
UNB-12	UNB-37	WC-12
UNB-17	GC-7	WC-18
	GC-8	

PRIORITY V

SR-1	WC-5	WC-10
WC-1	WC-6	WC-13
WC-2	WC-7	WC-14
WC-3	WC-8	PC
WC-4	WC-9	LNB

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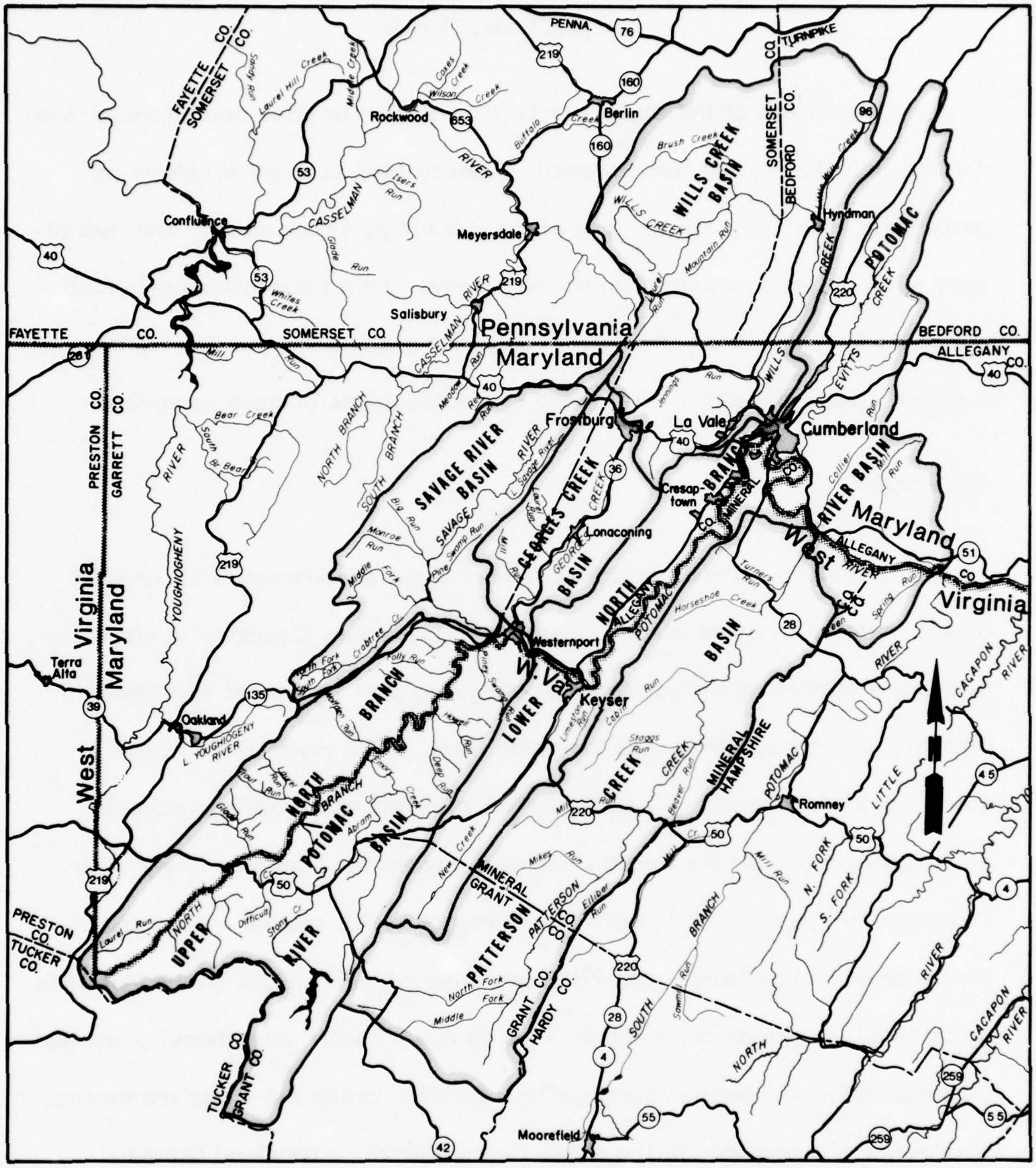
BASE CONDITIONS

BASE CONDITIONS

One aspect of the study involved definition of base conditions or the "no action" alternative for the basin — describing such parameters as geography, geology, climatology and air quality, water quality and hydrology, ecology, and socioeconomic conditions. This information provided the basis for prediction of future impacts of each recommended reclamation and abatement plan. Following are discussions of each parameter.

GEOGRAPHY

The North Branch Potomac River Basin encompasses all or part of six counties in three states: Garrett and Allegany Counties in Maryland, Grant and Mineral Counties in West Virginia, and Somerset and Bedford Counties in Pennsylvania (see Location Map). The river rises near the historic Fairfax Stone and flows for 98 miles alternately northeast and southeast to join the South Branch and form the Potomac River near Oldtown, Maryland. With a drainage area of 1,328 square miles, the North Branch constitutes approximately nine percent of the entire Potomac Basin area. Terrain of the study area is rugged with steep heavily wooded mountainsides and deep narrow valleys through which the river meanders. The western two-thirds of the basin lies within the Allegheny Plateau physiographic province while the eastern third is located on the margins



0 5 10 15 20 Statute Miles
0 5 10 15 20 25 30 Kilometers
Scale 1:500,000

LOCATION MAP

FIGURE 3

of the Ridge and Valley Province.

The Allegheny Plateau is a high, deeply dissected plateau bounded on the east by an eastward facing escarpment known as the Allegheny Front. This Allegheny Front is defined within the study area by the dissected ridge which forms the southeastern boundaries of the Upper North Branch, Georges Creek, and Wills Creek Basins. On the 1:150,000 scale map in the pocket of this report, that ridge extends southwest to northeast and bears the following names: 1) Fore Knobs; 2) Allegheny Front; 3) Dans Mountain; and 4) Wills Mountain. The province is drained by Stony River, the North Branch Potomac River, and New Creek which flow northeast, and the Savage River, Georges Creek and Wills Creek which flow southwest into the Potomac.

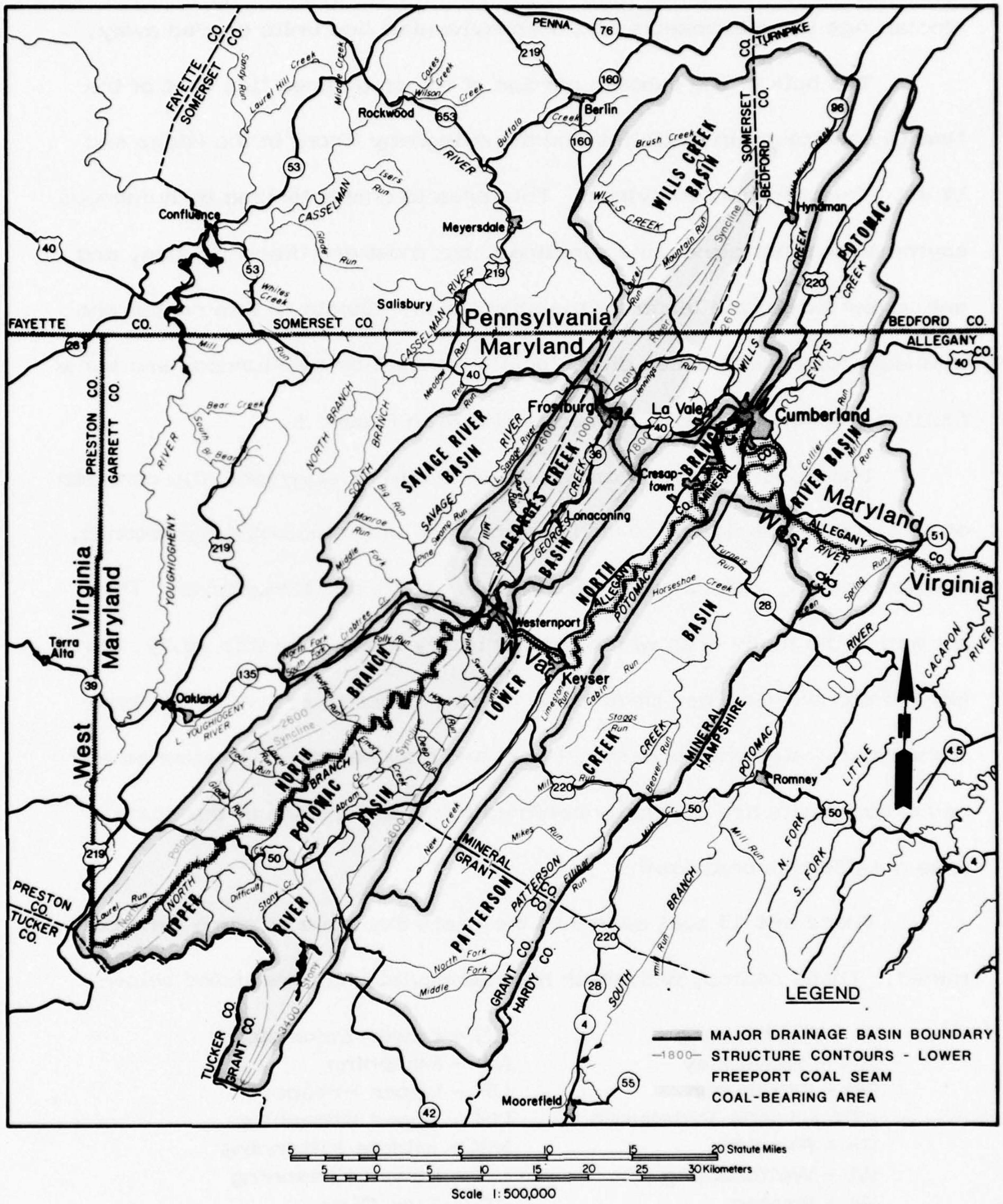
Only the westernmost portion of the Ridge and Valley Province lies in the study area. This region extends from the Allegheny Front to the Blue Ridge about 75 miles to the east. Characteristics of the province are the narrow parallel ridges and valleys running generally northeastward. Patterson Creek is the only tributary to the Potomac River in the study area which drains this province.

GEOLOGY

The North Branch Potomac River Basin structurally consists of

a series of parallel, northeast-southwest trending anticlines and synclines. The major structural features of the area have been delineated on the aerial photo composite maps developed for this study and are summarized in Figure 4, page 33. The most important structural feature in terms of this study is the symmetrical split synclinal basin extending from Pennsylvania through Frostburg, Maryland, and rising southwestward through the basin. This broad Georges Creek or North Potomac Syncline extends through Frostburg to Barnum, West Virginia, where it splits. The primary axis then extends west from Barnum and passes through Kempton, Maryland. The secondary synclinal axis — the Stony River Syncline — extends southwest from Barnum through the Stony River Reservoir. It is within this synclinal basin that the coal-bearing Pennsylvanian Age strata — the youngest geologic strata exposed within the study area — are found. Faulting is minimal; the coal-bearing units are relatively undisturbed structurally, and have been sheltered from the erosive forces which eliminated the coal deposits from the flanks of both adjacent anticlines.

Flanking the Georges Creek Syncline are the Deer Park Anticline to the west, the New Creek Mountain Anticline along the Allegheny Front to the east, and the Blackwater Anticline, which rises to the southwest between the two split synclines. Upon these anticlines, stratigraphically lower, geologically older rock units of Silurian, Devonian and Missis-



GEOLOGIC STRUCTURE MAP

FIGURE 4

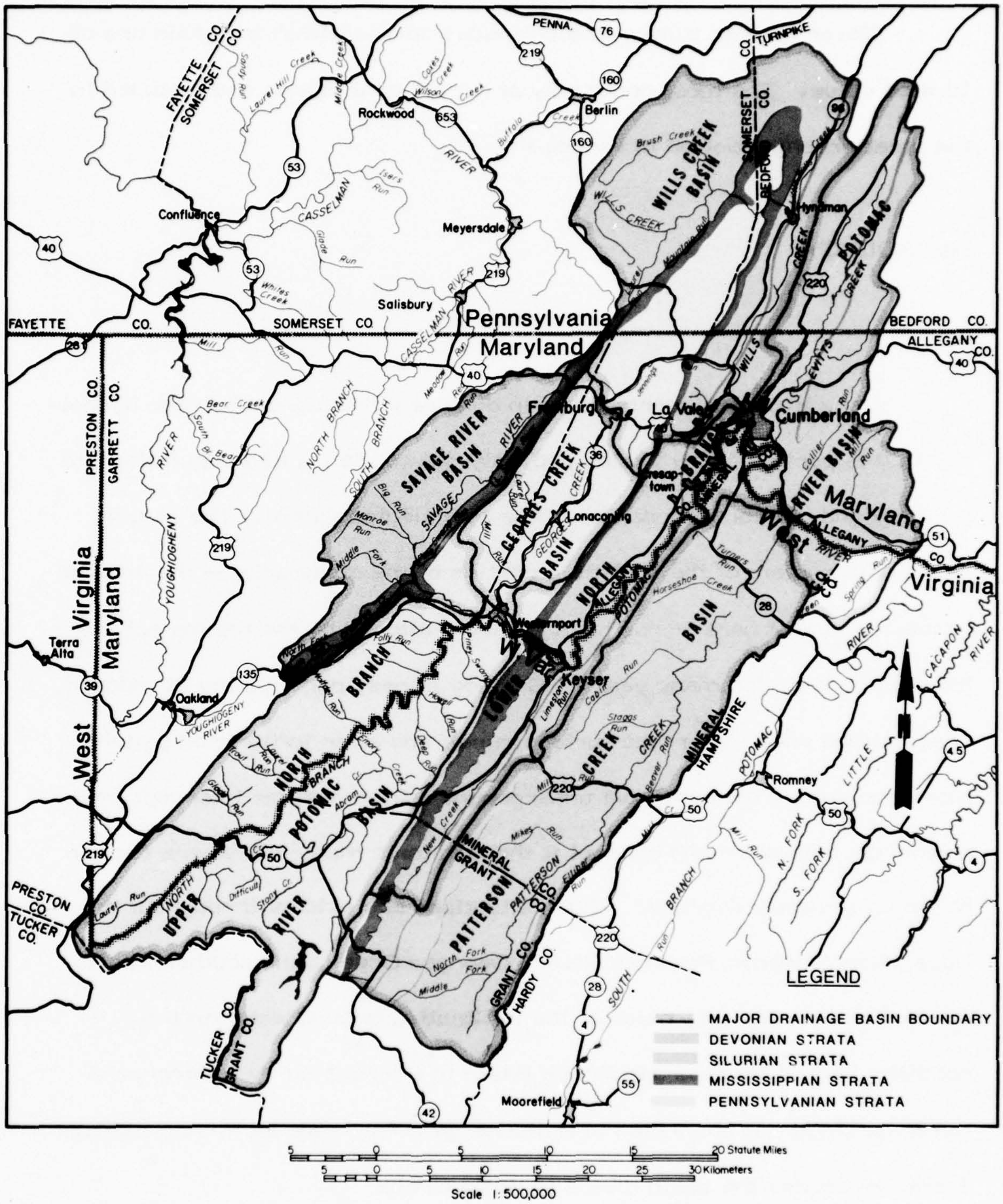
sippian Age were exposed as the Pennsylvanian Age units eroded away.

The bulk of the eastern portion of the study area lies east of the New Creek Mountain Anticline and the Allegheny Front in the Ridge and Valley Physiographic Province. This area is characterized by numerous asymmetrical anticlines and synclines, but most are discontinuous, and only a few extend the length of the study area. Strata in this region are intensely folded with steep dips, locally vertical or overturned, and some faulting. A general geologic map is shown in Figure 5.

The North Branch Potomac River Basin stratigraphically consists of an extensive series of bedded sedimentary units including sandstones, conglomerates, siltstones, shales, coals, clays and limestones. That portion of the study area which is of primary interest in this study, the North Potomac-Georges Creek Coal Basin, consists primarily of sandstones and shales with occasional coal and clay seams. Limestones and calcareous units are generally confined to those portions of the study area outside this coal basin.

There are 15 coal seams in the basin that have at some time been mined. These seams, with their map abbreviations, are listed below:

W - Waynesburg
SW - Sewickley
Pb - Pittsburgh
LPb - Little Pittsburgh
Fr - Franklin
Wl - Wellersburg
Br - Barton
Hl - Harlem
LB - Lower Bakerstown
Mh - Mahoning
UF - Upper Freeport
UK - Upper Kittanning
MK - Middle Kittanning
LK - Lower Kittanning
FC - Fire Clay



GENERAL GEOLOGY MAP

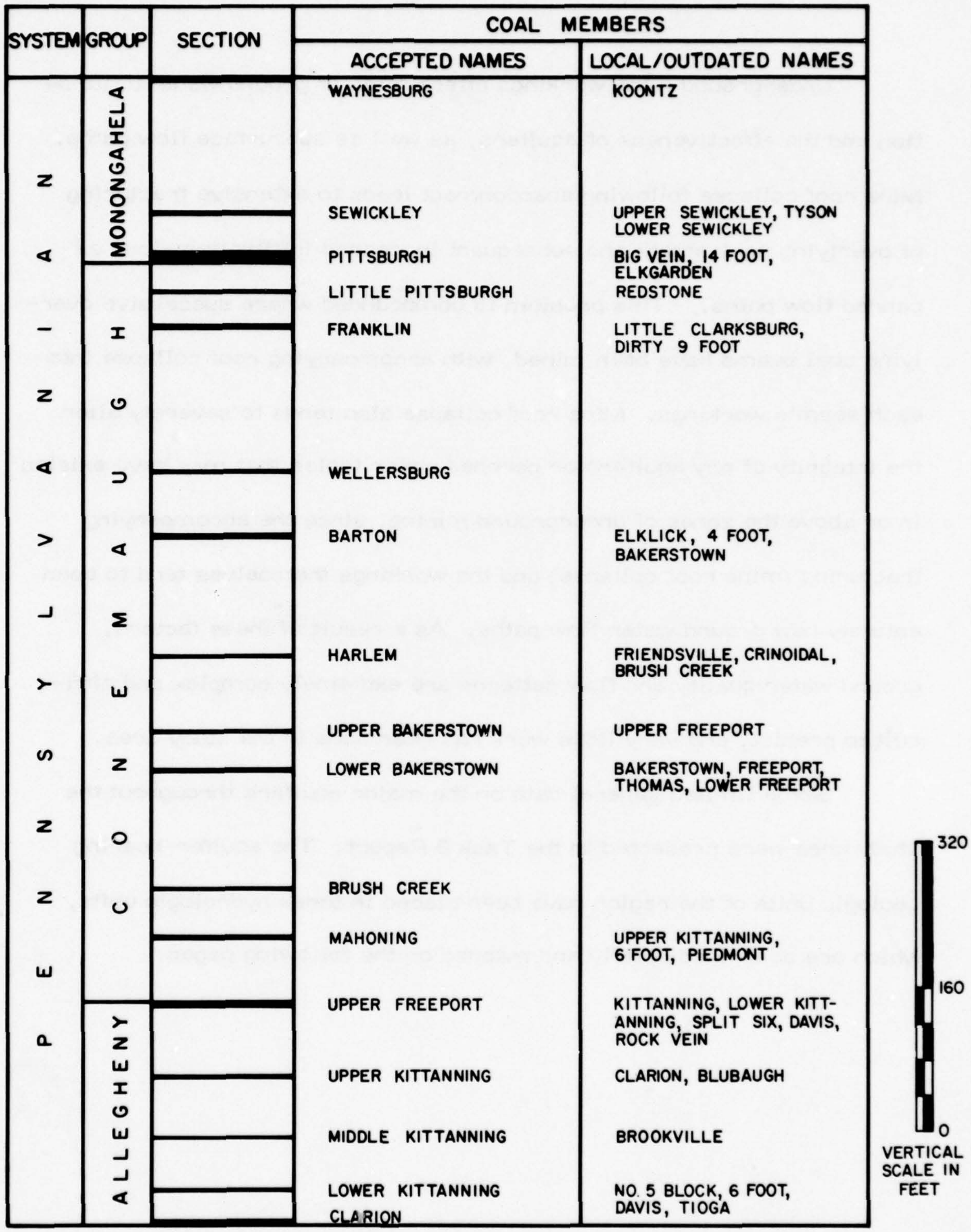
FIGURE 5

Several other thin or discontinuous seams within the basin are of limited value. The most commonly observed coal seams are included in the stratigraphic section in Figure 6.

HYDROLOGY

Ground Water

Very little past work has been done regarding ground water hydrology in this portion of the basin, probably due to the limited population and industry and the complex nature of the hydrologic system. The natural hydrologic system of the coal field portion of the study area — the area of greatest interest here — has been severely altered by the mining activity that has gone on for many years. Surface mines, particularly abandoned, unreclaimed ones, intercept surface runoff and alter infiltration patterns. More seriously, the extensive underground mine workings intercept infiltrating ground water and channel it through toxic materials where it often becomes severely degraded. Such situations are evident throughout the Upper North Branch Potomac River, Georges Creek, and southern Wills Creek Basins. In fact, much of the infiltrating ground water in the northern half of the Georges Creek Basin is intercepted by underground mine workings and channeled to a discharge point — the Hoffman Drainage Tunnel — across the basin divide in Wills Creek.



STRATIGRAPHIC SECTION SHOWING COAL SEAMS IN NORTH BRANCH POTOMAC RIVER BASIN

FIGURE 6

Underground mine workings affect rates of ground water infiltration and the effectiveness of aquifers, as well as subsurface flow paths. Mine roof collapse following abandonment leads to extensive fracturing of overlying rock strata and subsequent increased infiltration along expanded flow paths. This problem is compounded where successive overlying coal seams have been mined, with accompanying roof collapse into each seam's workings. Mine roof collapse also tends to severely alter the integrity of any aquifers or perched water tables that may have existed in or above the zones of underground mining, since the accompanying fracturing (mine roof collapse) and the workings themselves tend to open entirely new ground water flow paths. As a result of these factors, ground water quality and flow patterns are extremely complex and difficult to predict, and very little work has been done in the study area.

Some limited general data on the major aquifers throughout the study area were presented in the Task 3 Report. The aquifer-bearing geologic units of the region have been placed in three hydrologic units, which are described briefly and mapped on the following pages.

Hydrologic Unit I

Sandstone and limestone of the Valley and Ridge including: Oriskany Sandstone, Helderberg Limestone, and Tonoloway Limestone. (All such units lie east and west of the study area coal basin.)

Hydrologic Unit I contains the most productive aquifers within the area. It includes those formations in which average well yields and specific capacities fall in the upper 25 percent of a list of formations ranked according to their water-yielding characteristics.

The rocks in this unit are mainly carbonates subject to processes of solutional weathering and having a fair degree of permeability.

Yield (gpm)	Percent of Unit I Wells
0-5	17%
5-10	20%
10-25	34%
25-50	13%
50-100	8%
100-200	5%
200-300	2%
300-400	1%
400-500	1%

Hydrologic Unit II

Sandstones, shales, and shaley limestones of the Valley and Ridge and Appalachian Plateau including: Conemaugh Formation, Mauch Chunk Formation, Greenbrier Limestone, and Pocono Formation (this unit underlies the bulk of the study area coal basin).

Hydrologic Unit II contains those aquifers of intermediate productivity, and includes those geologic units in which average yields and specific capacities fall between 25 and 50 percent of a list of formations ranked according to their water-yielding characteristics.

This unit includes widely differing types of rocks, but is intermediate in hydrologic properties as indicated by the yields of wells and their specific capacities.

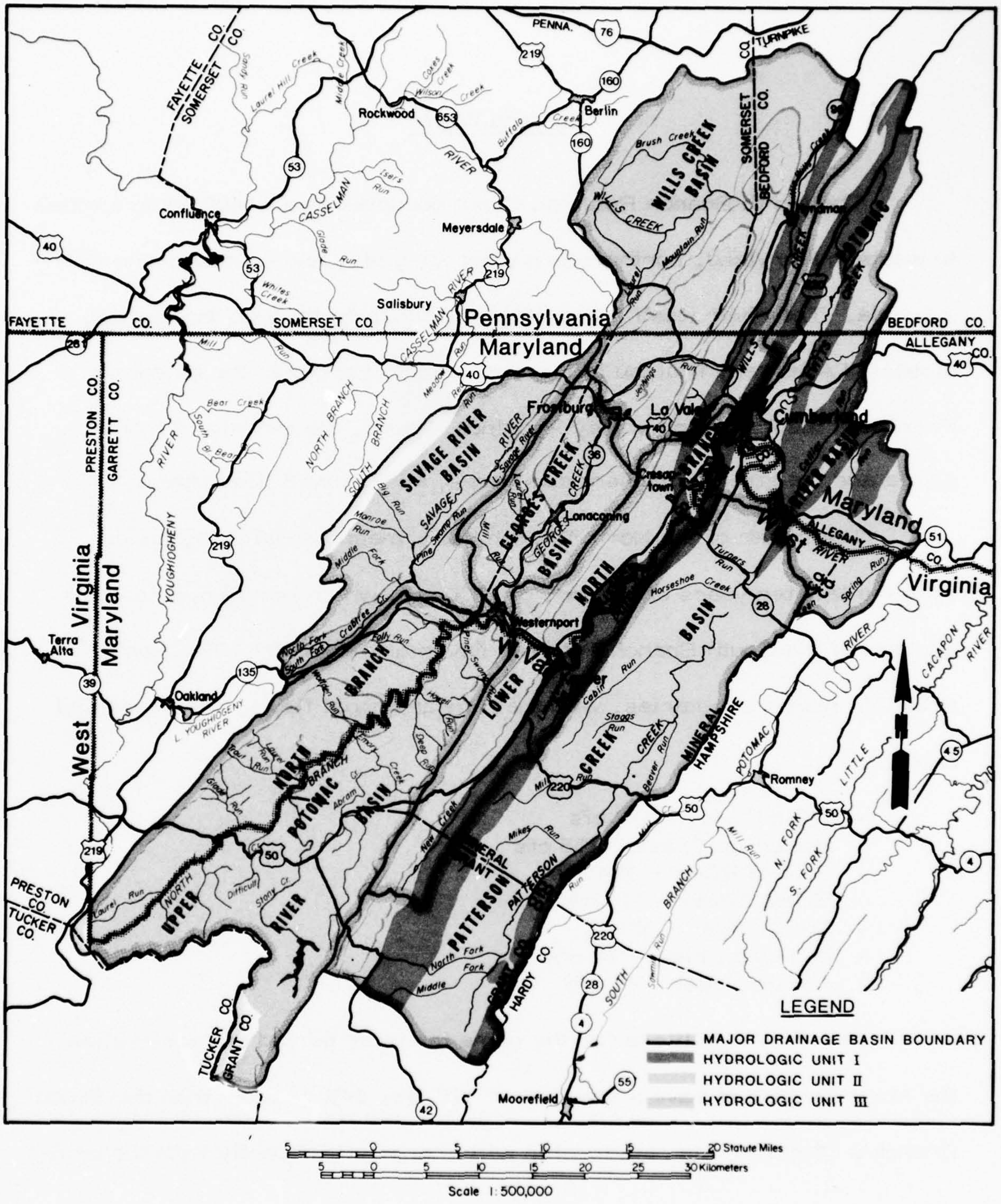
Yield (gpm)	Percent of Unit II Wells
0-5	23%
5-10	25%
10-25	38%
25-50	8%
50-100	4%
100-200	2%
200	0%

Hydrologic Unit III

Sandstones and shales of the Valley and Ridge and Appalachian Plateau including: Monongahela Formation, Allegheny and Pottsville Formations, Hampshire Formation, Jennings Formation, Romney Shale, Wills Creek Shale, Clinton Group, and Martinsburg Shale. (This unit also lies within the coal-bearing portions of the study area.)

Hydrologic Unit III contains the poorest aquifers within the study area. It includes those geologic units in which the average yields and specific capacities of wells fall in the lower 50 percent of a list of formations ranked according to their water-yielding characteristics.

Yield (gpm)	Percent of Unit III Wells
0-5	30%
5-10	29%
10-25	33%
25-50	6%
50-100	2%
100	0%



GENERAL HYDROLOGY MAP

FIGURE 7

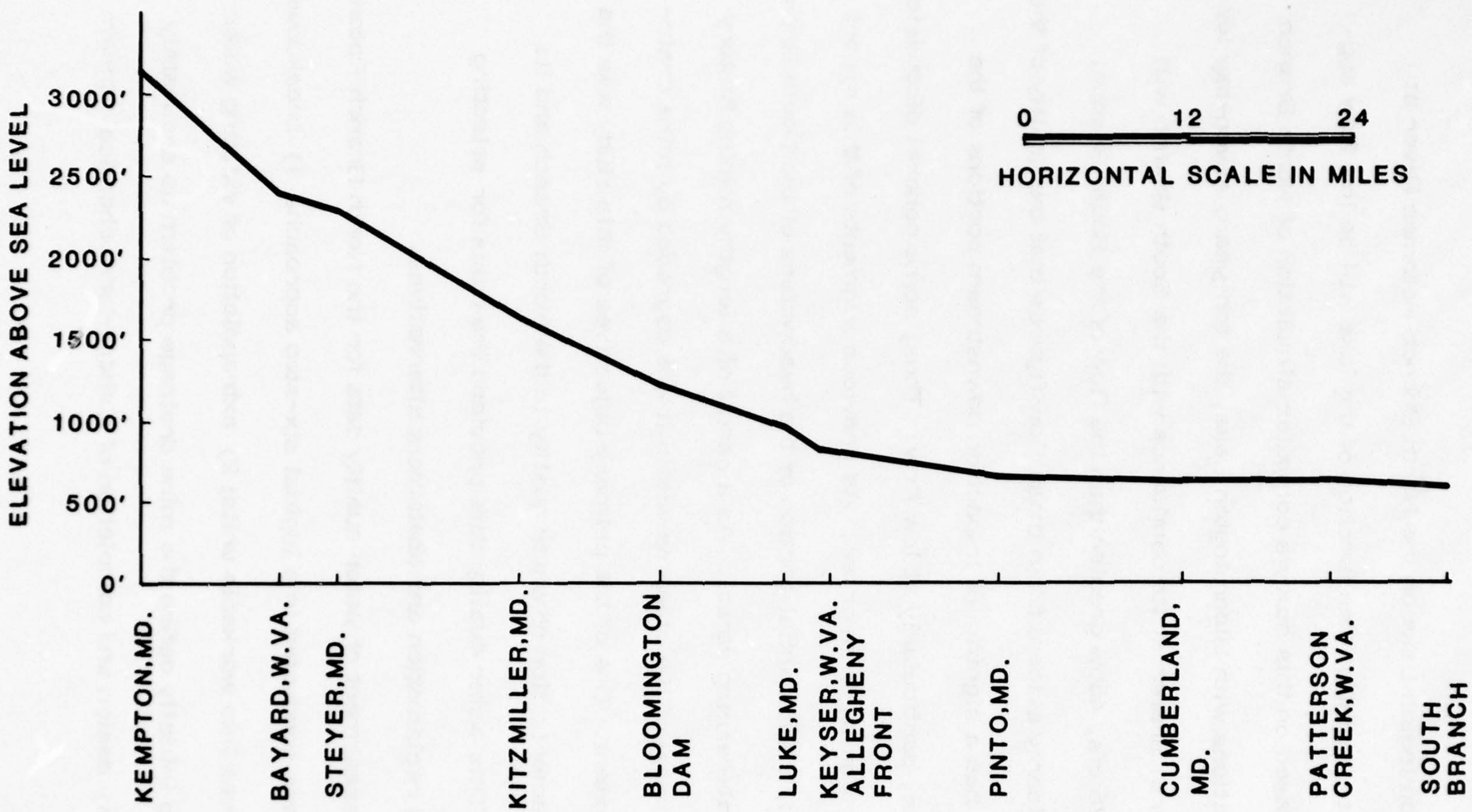
Surface Water

The North Branch Potomac Basin occupies about 1400 square miles in western Maryland, northeastern West Virginia, and southwestern Pennsylvania. The river itself flows rapidly downslope through the rugged, dissected Allegheny Plateau to Keyser, where it crosses the Allegheny Front into the Ridge and Valley Province. Here, the terrain is more gentle and the stream gradient decreases, as Figure 8 illustrates.

The mouth of the North Branch has a mean annual flow, based upon the last ten years of record, of 1800 cfs, which is 40% greater than the flow of the South Branch Potomac River at the mouth. The North Branch's major tributaries, with their mean annual flows, are presented below:

- Wills Creek - 318 cfs
- Patterson Creek - 165 cfs
- Savage River - 164 cfs
- Evitts Creek - 114 cfs
- Stony River - 96 cfs
- Georges Creek - 79 cfs
- Abram Creek - 66 cfs

Low flow conditions for the same ten-year period of record show the North Branch to have a low flow of 125 cfs, 84% greater than the South Branch's 68 cfs. This relationship will change significantly with the com-



STREAM GRADIENT
NORTH BRANCH POTOMAC RIVER BASIN
FIGURE 8

pletion of Bloomington Lake on the North Branch Potomac River at Barnum, West Virginia. One function of the lake will be low flow augmentation. Based on this study's computer simulation of North Branch Potomac conditions with Bloomington Lake, the ten-year, seven-day low flow of the North Branch at its confluence with the South Branch will increase to 375 cfs, 450% greater than the flow of the South Branch.

It is clearly evident from these flow figures that the quality of the North Branch has a significant impact on downstream portions of the Potomac Basin, particularly at low flow. Thus, some general discussion of basin water quality is in order. As previous segments of this report have indicated, a substantial portion of the headwaters of the North Branch lies within coal-bearing strata. As a result of a lengthy mining history in this area, many of the streams within it are degraded by mine drainage to some extent. One of the primary objectives of this study was the in-depth characterization of water quality in the North Branch and its tributaries. This water quality data provided the basis for selecting and assessing reclamation and abatement alternatives.

The assessment of water quality data for the North Branch Potomac River Basin was conducted in a logical six-step approach: 1) breakdown of the study area into workable units; 2) extrapolation of existing water quality data to initially define the mine drainage problem as accurately as possible; 3) design and completion of a short-term chemical stream

sampling program; 4) ranking of various working areas according to relative water quality; 5) definition of pollution sources; and 6) computer simulation of all data available to model basin water quality. These six steps are discussed fully in this study's Task Reports, and are summarized in the following pages.

The first step in the evaluation of North Branch Potomac River water quality was the definition of major basins and working watershed units within those basins to simplify subsequent data collection and evaluation efforts. Since they will be referred to throughout this report and subsequent Phase II activities, these basins and working watershed units are defined in Table 2 and mapped in Figure 9.

Step two basically involved collection and tabulation of available historical water quality data. Step three entailed design and completion of three stream sampling "runs" and compilation of resultant data with previously tabulated historical data. These data tabulations are included as Appendices of the Task 3 Report.

Based upon a careful assessment of this water quality data, a classification system was developed to permit rapid verbal and visual evaluations of stream quality in particular working watersheds and in individual modules within those watersheds. This stream classification system is summarized as follows:

Table 2

NORTH BRANCH POTOMAC RIVER BASIN
DESCRIPTIONS OF MAJOR BASINS
AND WORKING WATERSHEDS

Upper North Branch Potomac Basin – North Branch Potomac River Watershed Upstream From Powderhouse Run, Excluding Savage River and Georges Creek.

Watersheds

1. Main Stem North Branch – source to Wilsonia, West Virginia, tributary
2. Main Stem North Branch – Wilsonia, West Virginia tributary to mouth Red Oak Creek
3. Deaken Run
4. Elk Run
5. Laurel Run
6. Red Oak Creek
7. Sand Run
8. Main Stem North Branch – mouth Red Oak Creek to mouth Buffalo Creek
9. Shields Run
10. Buffalo Creek
11. Little Buffalo Creek
12. Main Stem North Branch – mouth Buffalo Creek to mouth Difficult Creek
13. Nydegger Run
14. Glade Run
15. Difficult Creek
16. Main Stem North Branch – mouth Difficult Creek to mouth Maple Run
17. Stony River above Stony River Dam
18. Stony River – Stony River Dam to Mt. Storm Dam
19. Stony River – Mt. Storm Dam to Mill Run
20. Stony River – Mill Run to mouth
21. Trout Run

Table 2 (Continued)

Upper North Branch Potomac Basin

22. Maple Run
23. Lostland Run
24. Main Stem North Branch - mouth Maple Run to mouth Wolfden Run
25. Short Run
26. Abram Creek above Duling Run
27. Abram Creek - mouth Duling Run to mouth Johnnycake Run
28. Abram Creek - mouth Johnnycake Run to mouth Emory Creek
29. Abram Creek - Emory Creek to mouth
30. Wolfden Run
31. Main Stem North Branch - mouth Wolfden Run to mouth Elklick Run
32. Three Forks Run
33. Deep Run
34. Howell Run
35. Elklick Run
36. Main Stem North Branch - mouth Elklick Run to mouth Savage River
37. Folly Run
38. Laurel Run
39. Piney Swamp Run
40. Main Stem North Branch - mouth Savage River to mouth Powderhouse Run

Savage River Basin

Watersheds

1. Savage River Watershed above Savage River Dam
2. Main Stem Savage River - Savage River Dam to mouth
3. Aaron Run

Table 2 (Continued)

Georges Creek Basin

Watersheds

1. Sand Spring Run
2. Main Stem Georges Creek - Wrights Crossing, Maryland, to Midland, Maryland
3. Winebrenner Run
4. Woodland Creek
5. Neff Run
6. Main Stem Georges Creek - Midland, Maryland, to Moscow, Maryland
7. Squirrel Neck Run
8. Elklick Run
9. Hill Run
10. Koontz Run
11. Jackson Run
12. Laurel Run
13. Main Stem Georges Creek - Moscow, Maryland, to mouth
14. Butcher Run
15. Moores Run
16. Unnamed tributary at Dogwood Flats, Maryland
17. Mill Run

Wills Creek Basin

Watersheds

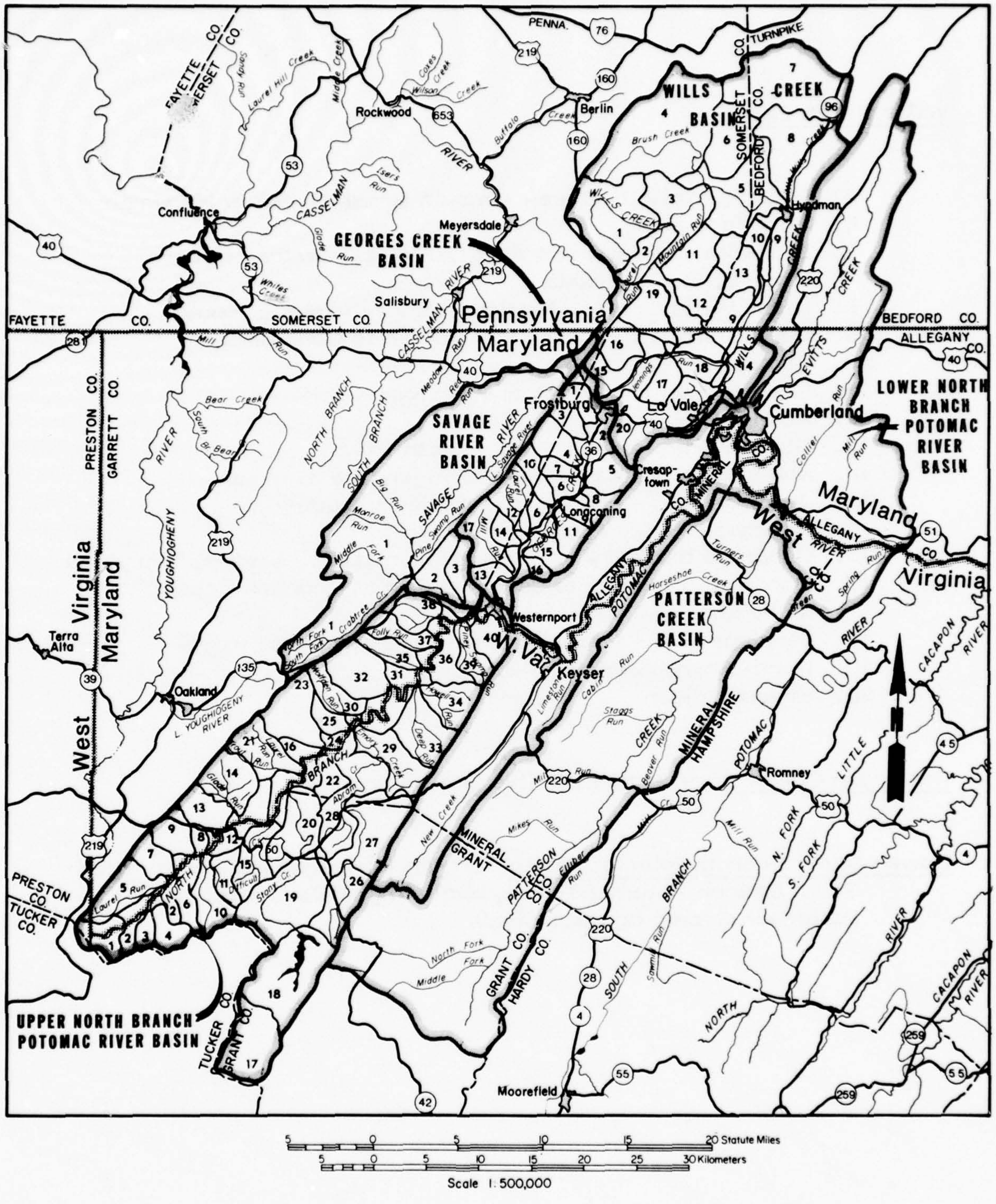
1. Main Stem Wills Creek - source to mouth Laurel Run
2. Laurel Run
3. Main Stem Wills Creek - mouth Laurel Run to mouth Brush Creek
4. Brush Creek

Wills Creek Basin

5. Main Stem Wills Creek - mouth Brush Creek to Hyndman
6. Schaffers Run
7. Little Wills Creek and Wolf Camp Run upstream from Madley, Pennsylvania
8. Little Wills Creek - Madley, Pennsylvania to mouth
9. Main Stem Wills Creek - Hyndman to Corriganville
10. Thompson Run
11. Gladden Run above mouth Rush Run
12. Rush Run
13. Gladden Run - mouth Rush Run to mouth
14. Main Stem Wills Creek - Corriganville to mouth
15. Jennings Run - source to unnamed tributary at Georges Creek, Maryland
16. Unnamed tributary to Jennings Run at Mt. Savage, Maryland
17. Unnamed tributary to Jennings Run at Georges Creek, Maryland
18. Jennings Run - Georges Creek, Maryland, to mouth
19. North Branch Jennings Run
20. Braddock Run

Patterson Creek Basin - all inclusive, no watersheds

Lower North Branch Potomac Basin - mouth Powderhouse Run to mouth South Branch Potomac River, excluding Wills Creek, and Patterson Creek; no watersheds



STUDY AREA WATERSHED UNITS

FIGURE 9

- Hot - Any module in which a net acidity was noted consistently.
- Marginal - Any module in which water quality noticeably fluctuated between net acidity and net alkalinity, either seasonally or on any other basis. In addition, any module in which sulfate concentration above 500 mg/l or a total iron concentration above 3 mg/l was noted. The latter two criteria indicate that a stream has been degraded by mine drainage at some point along its length, even if a net alkalinity is in evidence at the sample point.
- Cold - Areas in which no significant water quality impact is attributable to mine drainage pollution.

This hot-marginal stream classification is visually illustrated on the color base map developed for this study, included in the pocket at the back of this report.

One of the primary objectives of this study was the characterization of pollution sources — active versus inactive or abandoned and surface versus underground. Based on study findings, a substantial portion of the mine drainage pollution degrading West Virginia tributaries to the North Branch is associated with recent, but not active, mining activities. On the other hand, the North Branch tributaries on the Maryland side of the basin are primarily degraded by abandoned mine discharges. In fact, historical data, current sampling, and reconnaissance efforts did not reveal any major Maryland sources of mine drainage that were associated with recent mining. Brief descriptions of the sources of pollution — active

versus inactive and surface versus underground mines — in each of the study area's working watershed units were presented in the Task 3 Report. Those conclusions are preliminary, based upon "broad-brush" reconnaissance efforts, and may change somewhat during Phase II, when intensified reclamation and abatement feasibility studies are conducted in individual working watersheds.

One further step in the determination of specific mine drainage pollution source areas was the use of existing data to locate and characterize mine drainage discharge points. These points were located on the photomaps developed for this study, and represent historical data for the most part, since actual discharge sampling was not within Phase I's scope of work. Such sampling will be performed in subsequent Phase II detailed watershed or module investigations. Included in this point source mapping are data generated in a number of previous studies of various portions of the North Branch Potomac River Basin and all active mine discharges — primarily those permitted under the National Pollutant Discharge Elimination System (NPDES) — as of June, 1976. These active discharges must remain in compliance with State water quality regulations — shown in Tables 6 and 7 of the Task 3 Report and with the U.S. Environmental Protection Agency's effluent limitations. The tabulated point source data was included as an Appendix to the Task 3 Report.

One of the primary tools used for evaluating the amassed water quality data for the study area was the North Branch Potomac River Simulation Model developed by Water Resources Engineers, Inc. (WRE). WRE used the model they previously developed for the Corps of Engineers, modifying it extensively to reflect the additional data generated in the current study. These modifications included the addition of new simulation points — nodes — and the development of several sub-programs for individual watersheds or basins. A complete description of the simulation procedure is presented in the Task 4 Report, and a summary of the current computer simulation programs follows:

- North Branch Potomac River Main Stem - The updated version of WRE's original model, containing 78 nodes and a Bloomington Lake simulation.
- Abram Creek - A 14-node sub-program.
- Stony River - A 7-node sub-program.
- Georges Creek - A 38-node sub-program.
- Wills Creek - A 40-node sub-program.

Although these sub-programs were used during the simulation process, the mouths of the respective streams were still represented in the main simulation. Thus, any abatement alternatives affecting these smaller basins was first modeled on the small basin simulation model to determine resultant water quality at the tributary mouth. This stream mouth water quality was then plugged into the main North Branch Potomac simulation, to ascertain impacts of the proposed alternatives on that stream.

Since the main stem program was deemed most important in accurately modeling water quality conditions, a great deal of thought went into its development. In fact, three distinct programs were developed representing study area base conditions:

- Confirmed 1976 Base Conditions
- Projected Base Conditions (without Bloomington Lake)
- Projected Base Conditions with Bloomington Lake

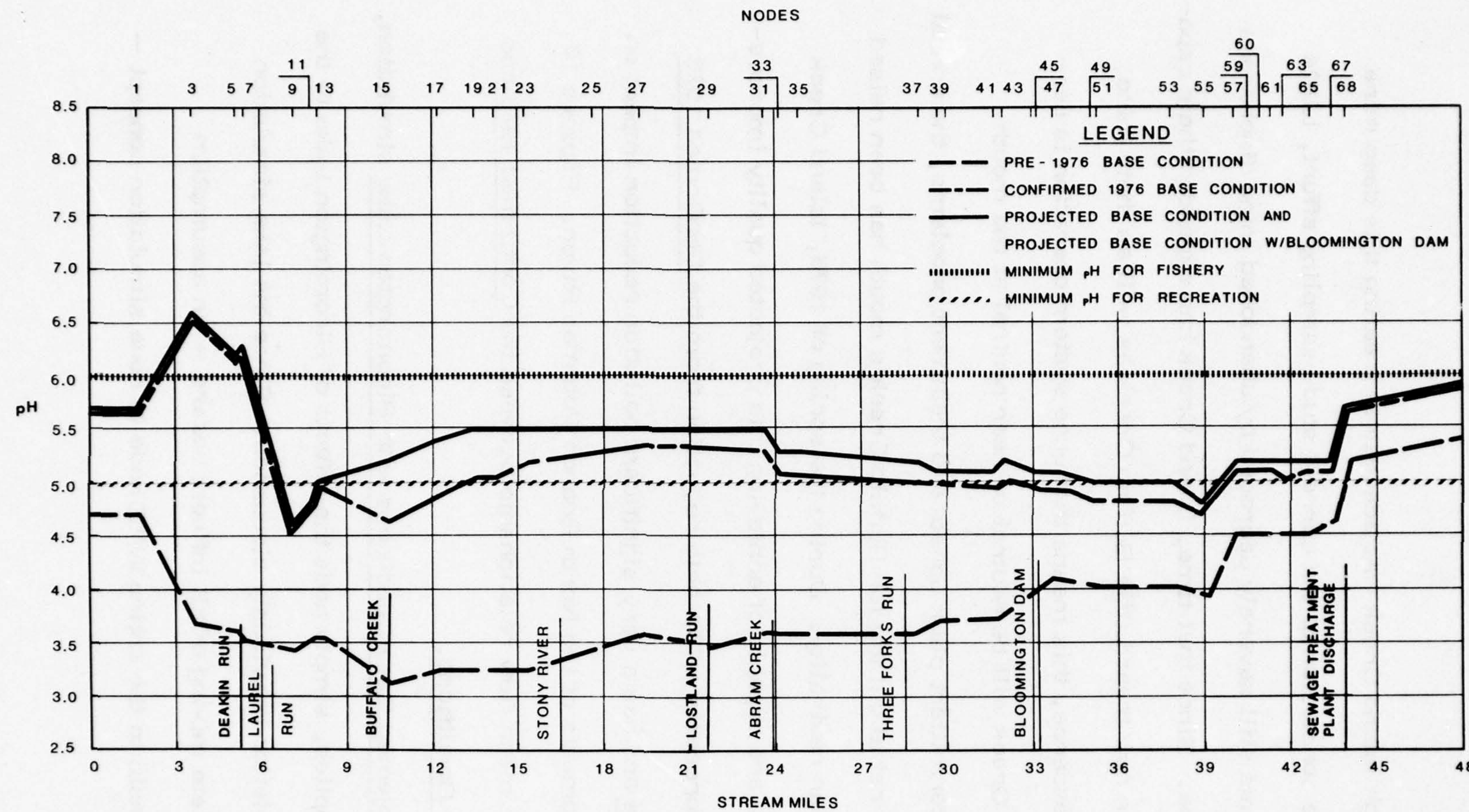
The Confirmed 1976 Base Conditions represent the original WRE program updated and weighted rather heavily toward the most recently acquired water quality data — primarily that generated in the current study sampling program.

The Projected Base Conditions go a step beyond the previous simulation in characterizing or projecting changes in basin water quality that are now occurring or have occurred since the latest current study sampling effort. Two primary tributary improvements are simulated. Daylighting of an abandoned underground mine — the "Deer Park Daylighting Project" — is now being demonstrated in the Lostland Run Watershed. Initial projections by the agencies involved in this demonstration project indicate a 35% reduction in Lostland Run's acid load. This reduction has been incorporated into the Projected Base Conditions.

A massive expansion of mine drainage treatment facilities has also occurred at Island Creek's North Branch Mine on Little Buffalo

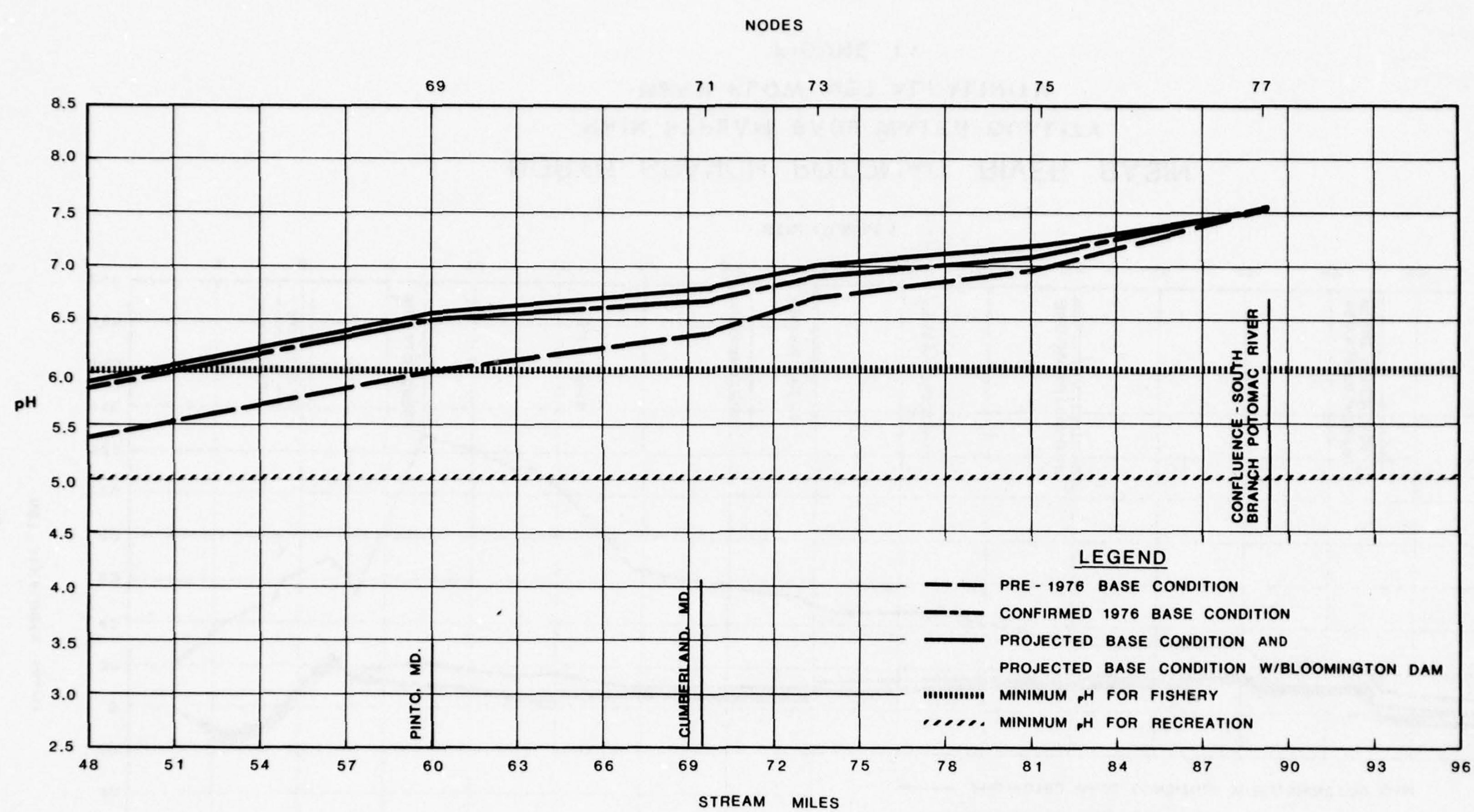
Creek. Although Island Creek was adequately treating this deep mine discharge at the conclusion of the current study sampling effort, Little Buffalo Creek was still severely degraded by abandoned mine discharges in the same area. Since that time, Island Creek has expanded their capabilities, and can now treat Little Buffalo Creek as well as their mine discharge. In essence, this means that once system operation is perfected, Buffalo Creek will be neutral or near neutral at the mouth. Allowing for intermittent plant upsets and treatment problems, the annual mean projected net alkalinity for Buffalo Creek's mouth has been raised to -20 mg/l, near neutrality. During the spring of 1976, Island Creek proved that they are capable of achieving this projected quality improvement, which represents a 75% acid reduction from the Confirmed 1976 Base Conditions and has a very significant pollution reduction impact on downstream segments of the North Branch Potomac River. Figures 10 and 11 show the mean flow relationship between the Confirmed 1976 and Projected Base Conditions.

The Projected Base Conditions with Bloomington Lake simulation, as the name implies, simply adds the effects of Bloomington Lake to the Projected simulation previously discussed. Since the lake simulation assumes complete mixing of all influent waters — an assumption which is also basic to the entire WRE node to node simulation concept —



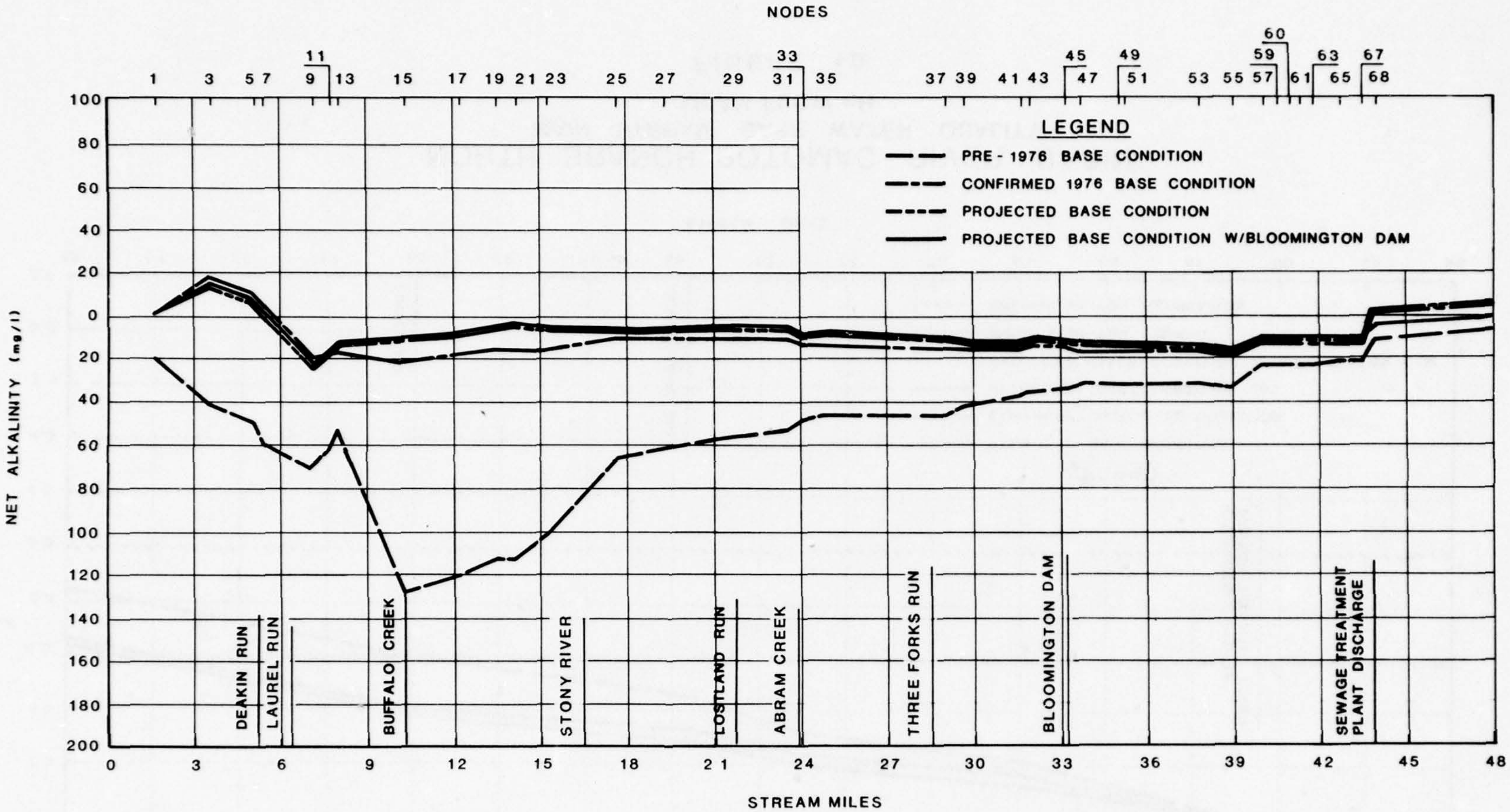
NORTH BRANCH POTOMAC RIVER BASIN
MAIN STREAM BASE WATER QUALITY
MEAN FLOW pH

FIGURE 10

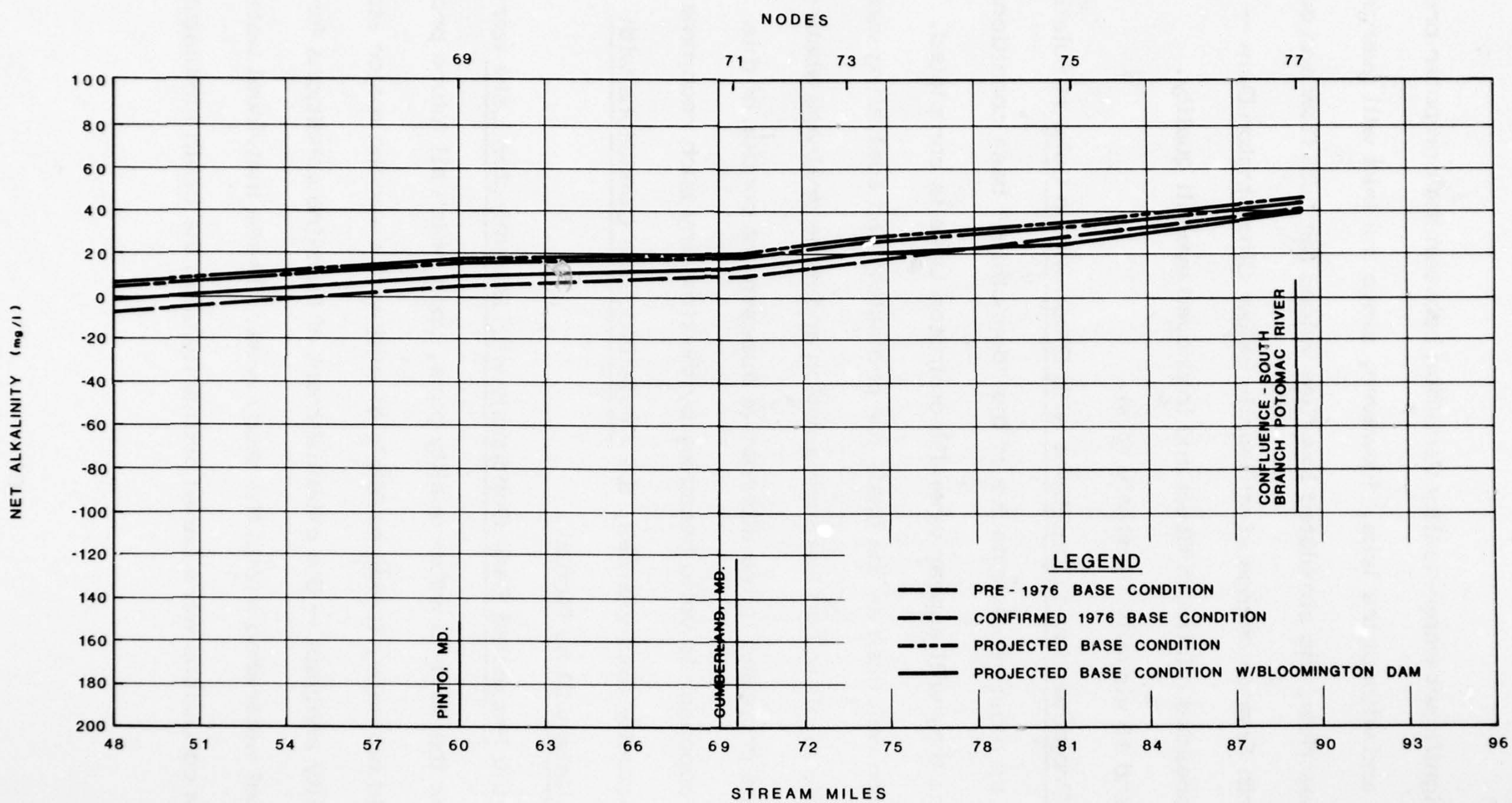


NORTH BRANCH POTOMAC RIVER BASIN
MAIN STREAM BASE WATER QUALITY
MEAN FLOW pH

FIGURE 10



NORTH BRANCH POTOMAC RIVER BASIN
MAIN STREAM BASE WATER QUALITY
MEAN FLOW NET ALKALINITY
FIGURE 11



NORTH BRANCH POTOMAC RIVER BASIN

MAIN STREAM BASE WATER QUALITY

MEAN FLOW NET ALKALINITY

FIGURE 11

there is no significant water quality variation between the computer projections with and without the lake. However, since the lake will guarantee a minimum low flow, the simulated low flow values for both flow and quality in the North Branch change significantly below Bloomington Dam — reflecting increased minimum flows and improved overall quality. (Figures 12 and 13 visually illustrate this).

This Projected Base Conditions with Bloomington Lake simulation was selected as most representative of the "do-nothing" base conditions in the basin as they will appear when Bloomington Lake is completed. This simulation was used as the basis for projecting and evaluating water quality impacts of all mined land reclamation and mine drainage abatement activities proposed in the alternative assessment portion of this study. This approach is valid because, by the time any such recommendations are actually implemented, the Projected Base Conditions with Bloomington Lake will be factual.

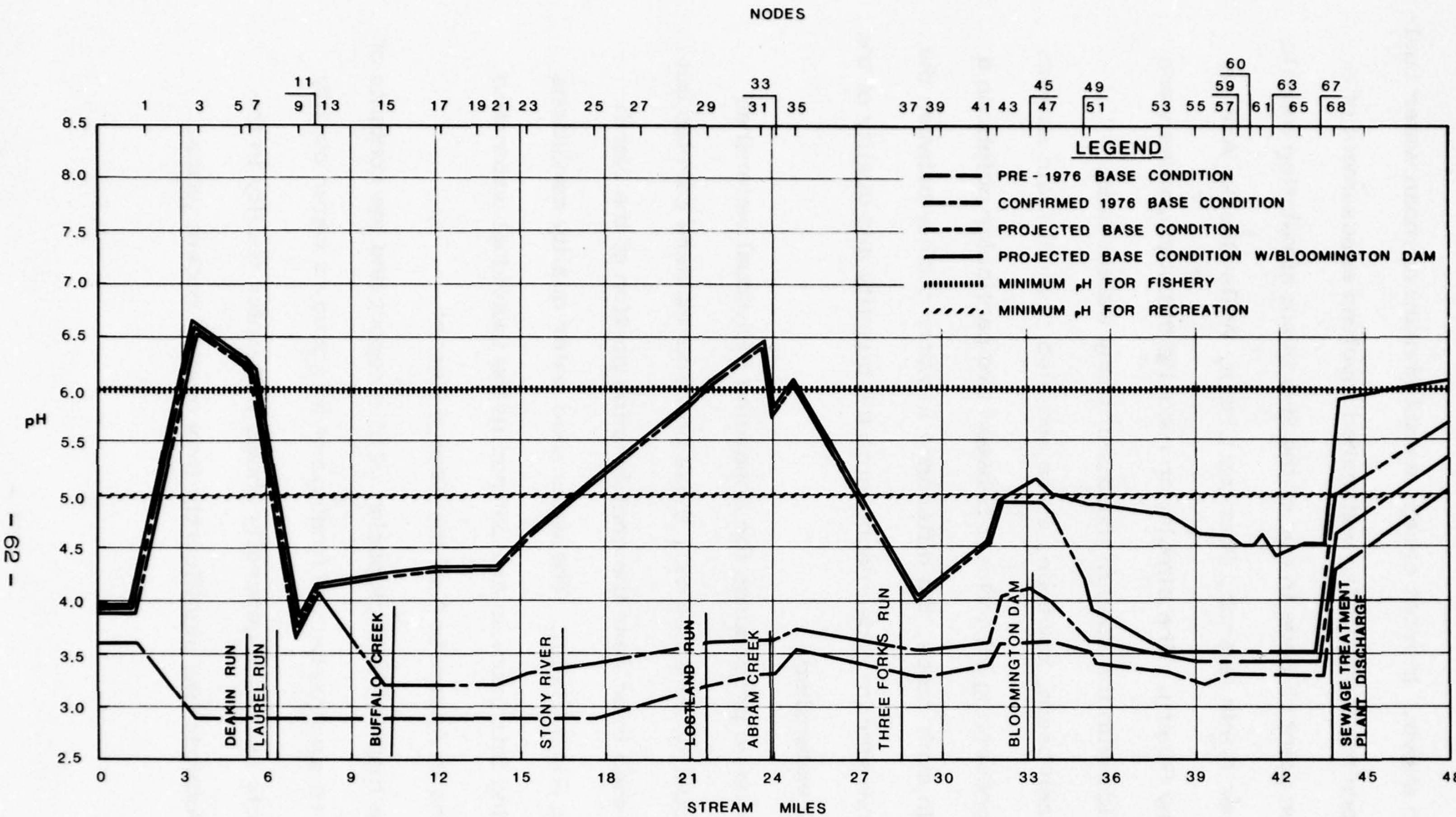
Once the Projected Base Conditions with Bloomington Lake were established as the study's water quality base, upon which all future projections would be made, it was possible to initiate the second major stage of water quality analysis — the establishment of baseline conditions for each individual watershed within the study area. These individual watershed baseline conditions were based primarily upon the basin simulation

model described above. In most cases, establishment of mean water quality base conditions for a particular watershed involved assessment of a single simulation point or node in one of the five basin simulation models (Main Stem Upper North Branch, Georges Creek, Wills Creek, Abram Creek, and Stony River). The simulation model's tributary nodes were located to coincide with the stream mouths of many watersheds.

Within each basin, however, there are also several main stream watersheds, representing all influent between two particular points on a main stream. In such cases, the difference in water quality between the upstream and downstream nodes represents the quantity and quality of the net influx in that watershed.

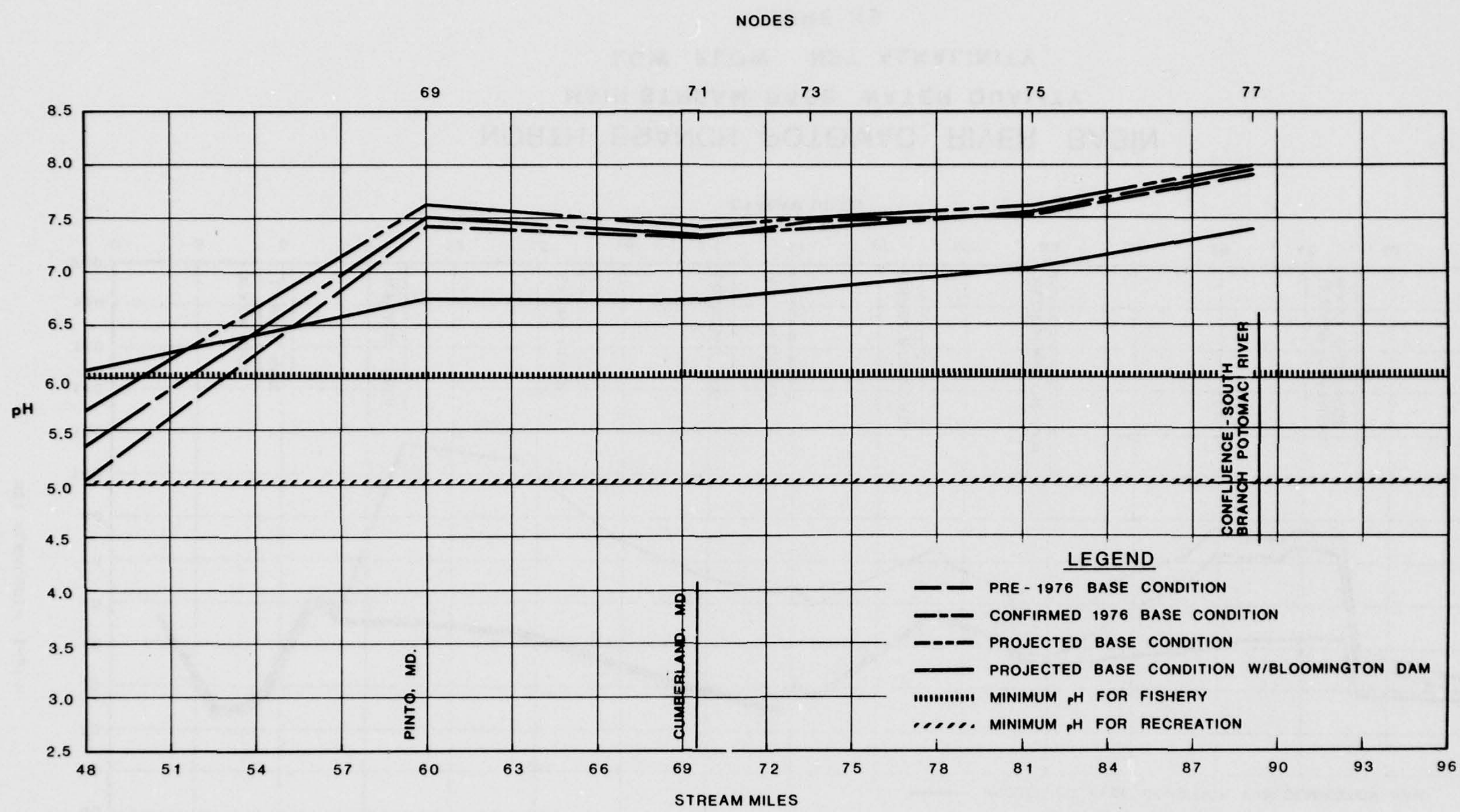
Once the basic procedures for assessing individual watershed baseline water quality were defined, those procedures were carried out for every watershed in or near the coal-bearing portion of the North Branch Potomac River Basin. The watershed water quality conditions established during this process are defined in the individual watershed characterizations in Appendix A of the Task 4 Report.

The base map in the back pocket of this report and the contents of Figures 14 and 15 summarize the findings of this study's water quality evaluations. Data assessed generally shows that water quality in the North Branch Potomac has significantly improved in recent years.



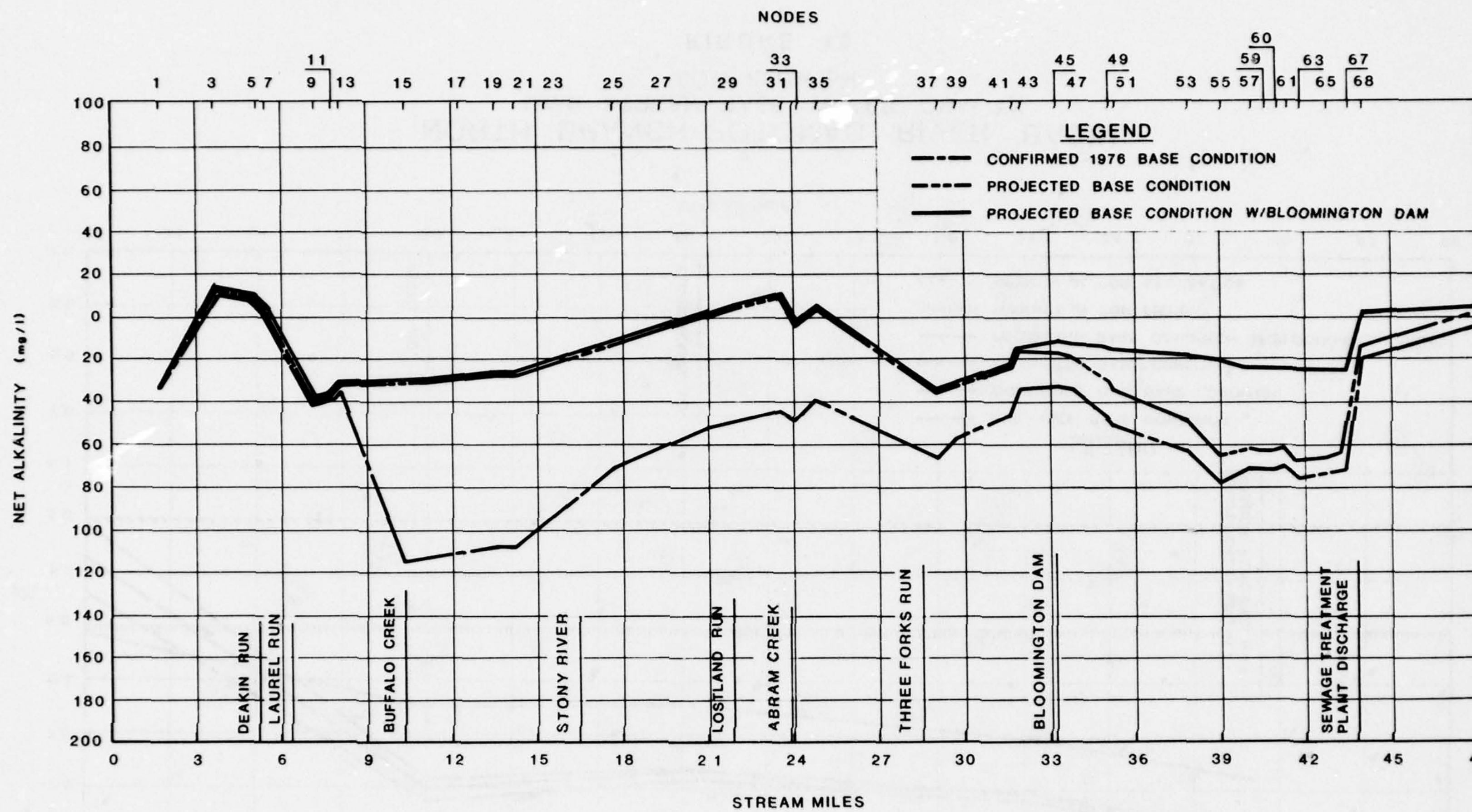
NORTH BRANCH POTOMAC RIVER BASIN
MAIN STREAM BASE WATER QUALITY
LOW FLOW pH

FIGURE 12



NORTH BRANCH POTOMAC RIVER BASIN
MAIN STREAM BASE WATER QUALITY
LOW FLOW pH

FIGURE 12

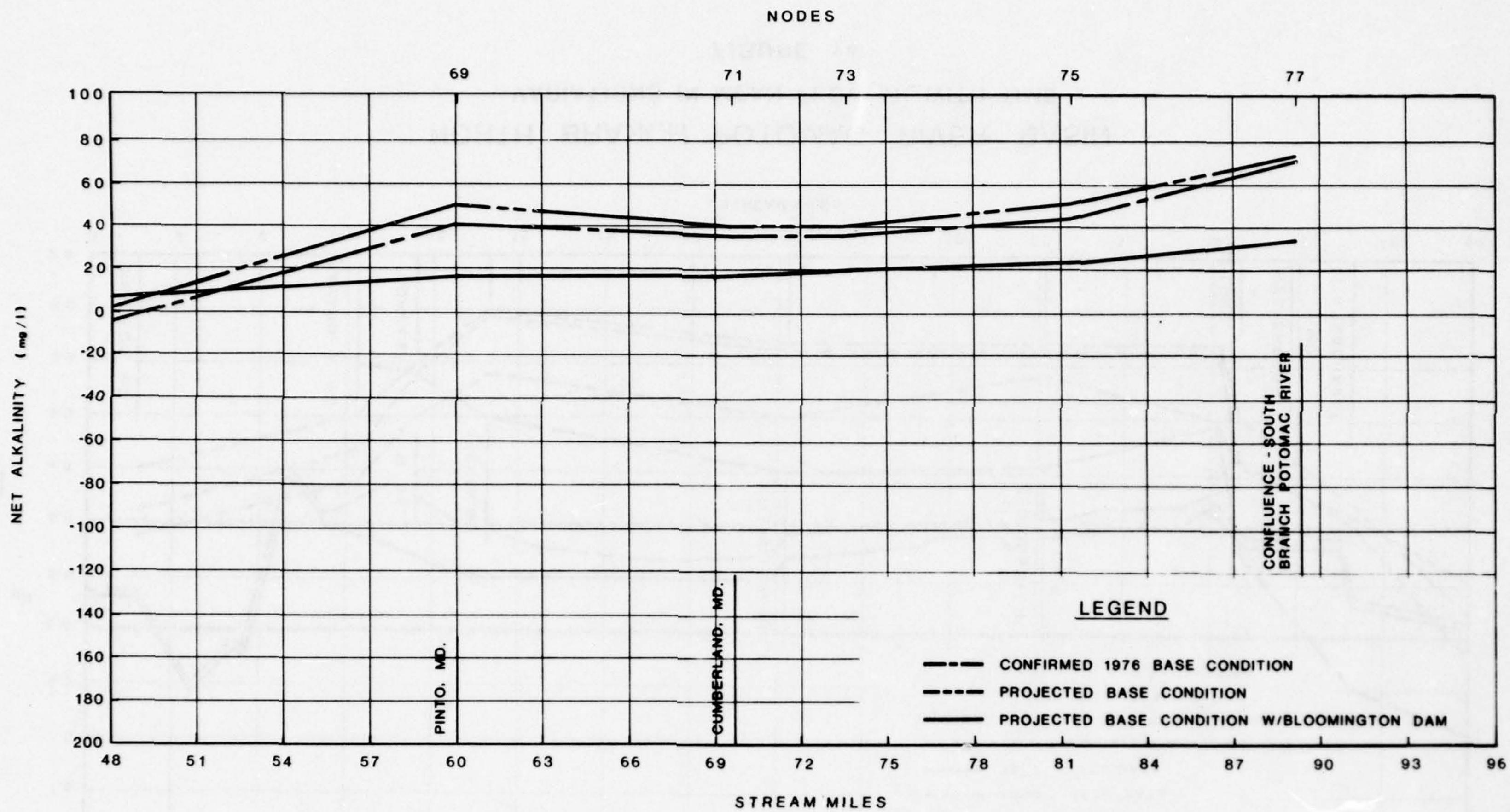


NORTH BRANCH POTOMAC RIVER BASIN

MAIN STREAM BASE WATER QUALITY

LOW FLOW NET ALKALINITY

FIGURE 13

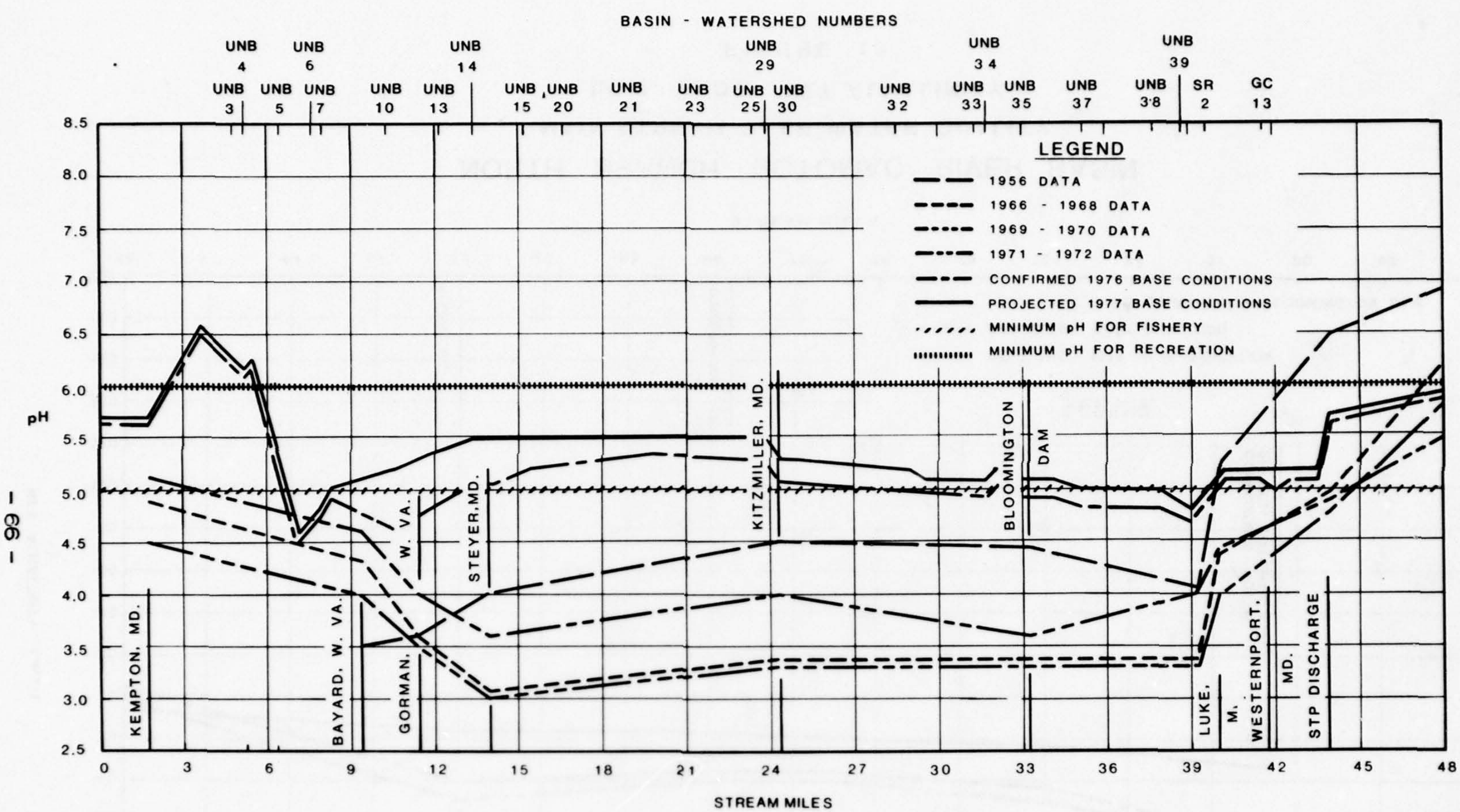


NORTH BRANCH POTOMAC RIVER BASIN

MAIN STREAM BASE WATER QUALITY

LOW FLOW NET ALKALINITY

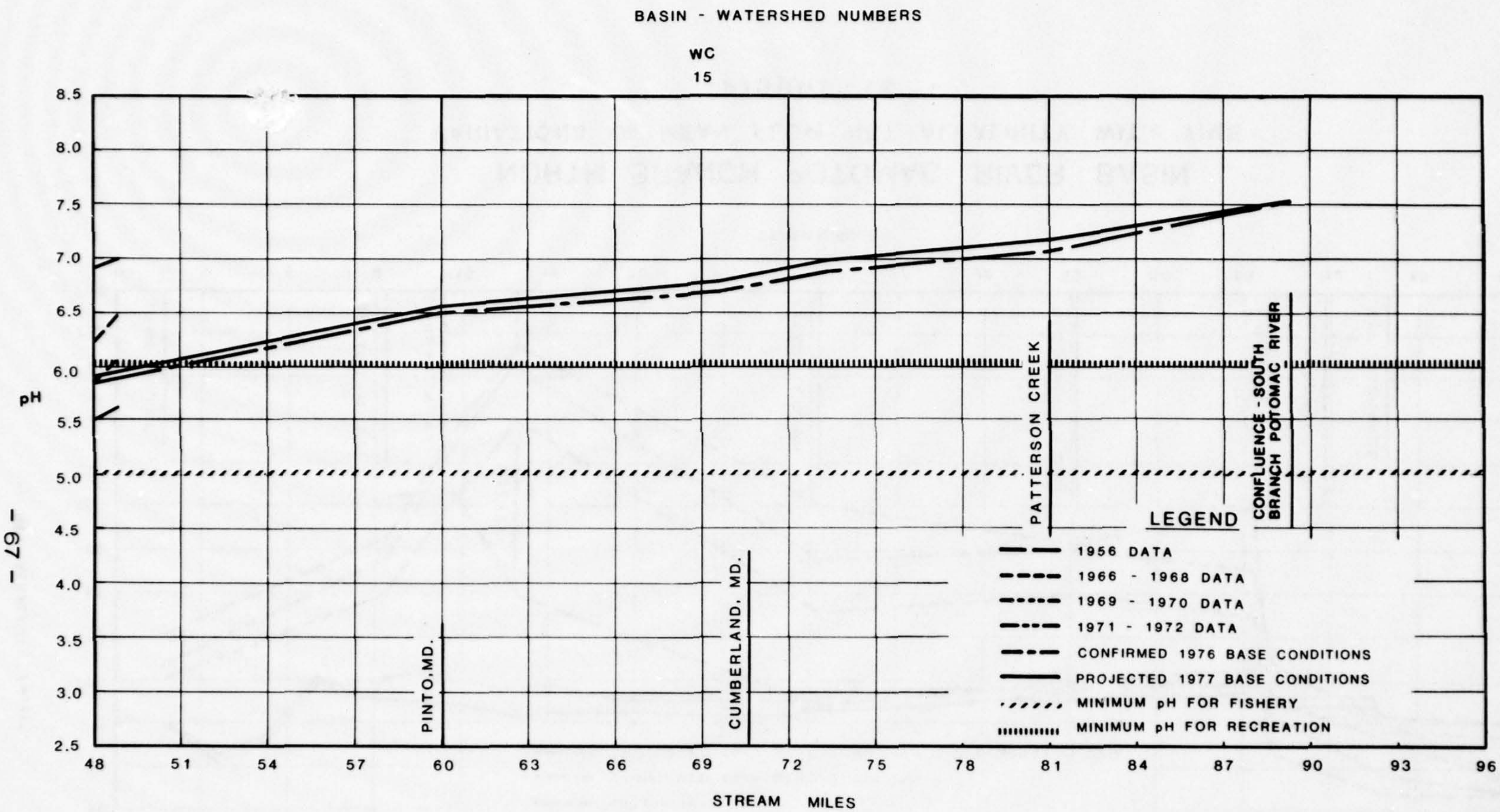
FIGURE 13



NORTH BRANCH POTOMAC RIVER BASIN

VARIATIONS IN MEAN FLOW pH WITH TIME

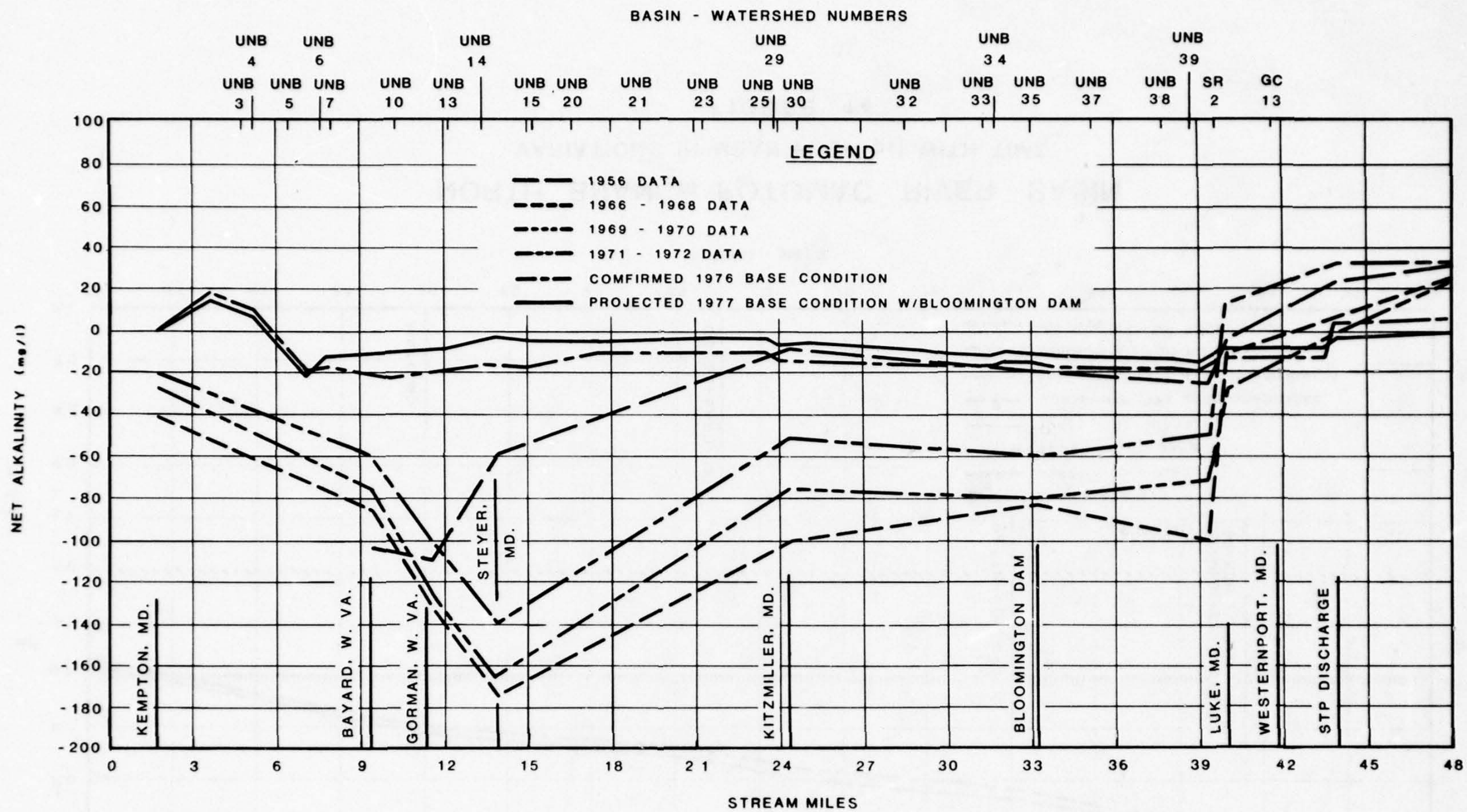
FIGURE 14



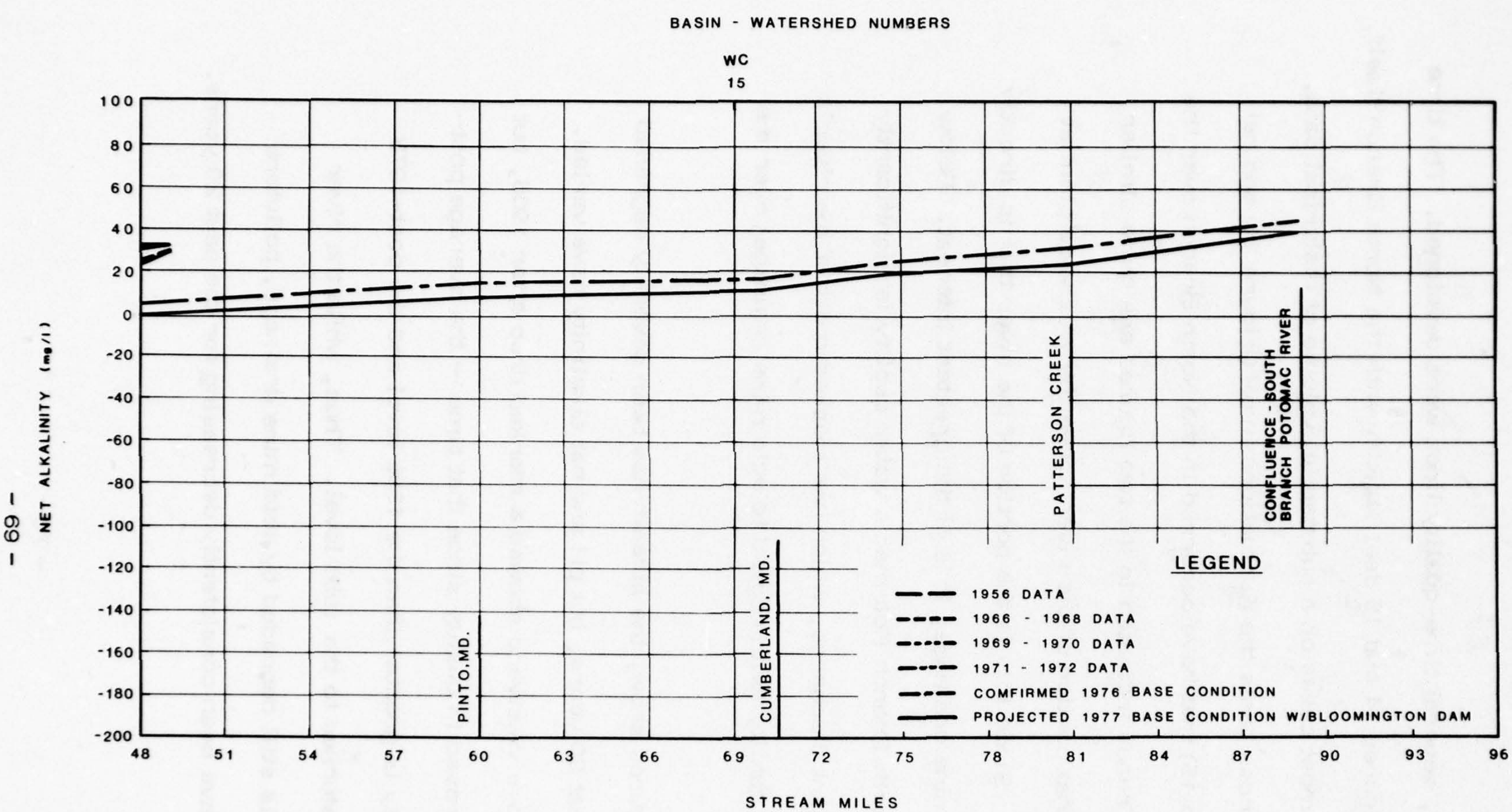
NORTH BRANCH POTOMAC RIVER BASIN

VARIATIONS IN MEAN FLOW pH WITH TIME

FIGURE 14



NORTH BRANCH POTOMAC RIVER BASIN
VARIATIONS IN MEAN FLOW NET ALKALINITY WITH TIME
FIGURE 15



NORTH BRANCH POTOMAC RIVER BASIN
VARIATIONS IN MEAN FLOW NET ALKALINITY WITH TIME
FIGURE 15

To illustrate this, several time-quality lines were developed. The time lines shown in Figures 14 and 15 deal strictly with the North Branch itself, and are based in most cases on a substantial volume of historical data. They show on a gross basis the fluctuations in pH (Figure 14) and net alkalinity (Figure 15) that have occurred in the North Branch over the past 20 years. Trends indicated in the two figures are quite similar, particularly for that portion of the river above the Westvaco plant at Luke, Maryland. Since this is the portion of the river that is directly affected by acid mine drainage, it is of the greatest interest. Below Westvaco, the North Branch Potomac's water quality is significantly affected by the plant discharge, which has masked most of the river's improvements in quality (with regard to acid mine drainage) over the past 20 years.

As the figures show, the stream has been severely degraded throughout the past 20 years, but pH and net alkalinity have varied. Water quality above Westvaco showed a marked drop after 1956, but has steadily improved in quality since that time — the average post-1973 net alkalinity is greater than the 1956 level and the post-1973 pH has almost returned to the 1956 level. Thus, while the river above Westvaco is still degraded by acid mine drainage, pollutant concentrations have been consistently decreasing for the past 20 years.

Despite the illustrated improvements in water quality above Westvaco, the figures show that the pH and net alkalinity of the North Branch below Westvaco have been dropping in recent years — although still well within acceptable limits. This reflects the EPA-mandated clean-up of Westvaco's discharge, which was at one time very highly alkaline. As the alkalinity of this discharge dropped in recent years, its ability to neutralize acid in the North Branch also decreased resulting in the noted drops in overall pH and net alkalinity.

A second water quality characteristic worthy of discussion is the extremely low iron and sulfate levels exhibited in many acceptable and polluted streams. The bulk of the data examined reflected this trend, suggesting that natural background levels of iron and sulfate are extremely low in the study area. The only streams showing high iron and sulfate concentrations typical of mine drainage were, for the most part, those degraded by discharges from abandoned underground mines.

A third general water quality observation is closely related to the previous point. Early in the study it was observed that not only iron and sulfate levels, but also alkalinity levels in unpolluted streams were extremely low. This is attributed to the low-alkaline nature of the streambed geologic strata within the North Branch Potomac Basin. The study area's streams have very little buffering capability; that is, there is

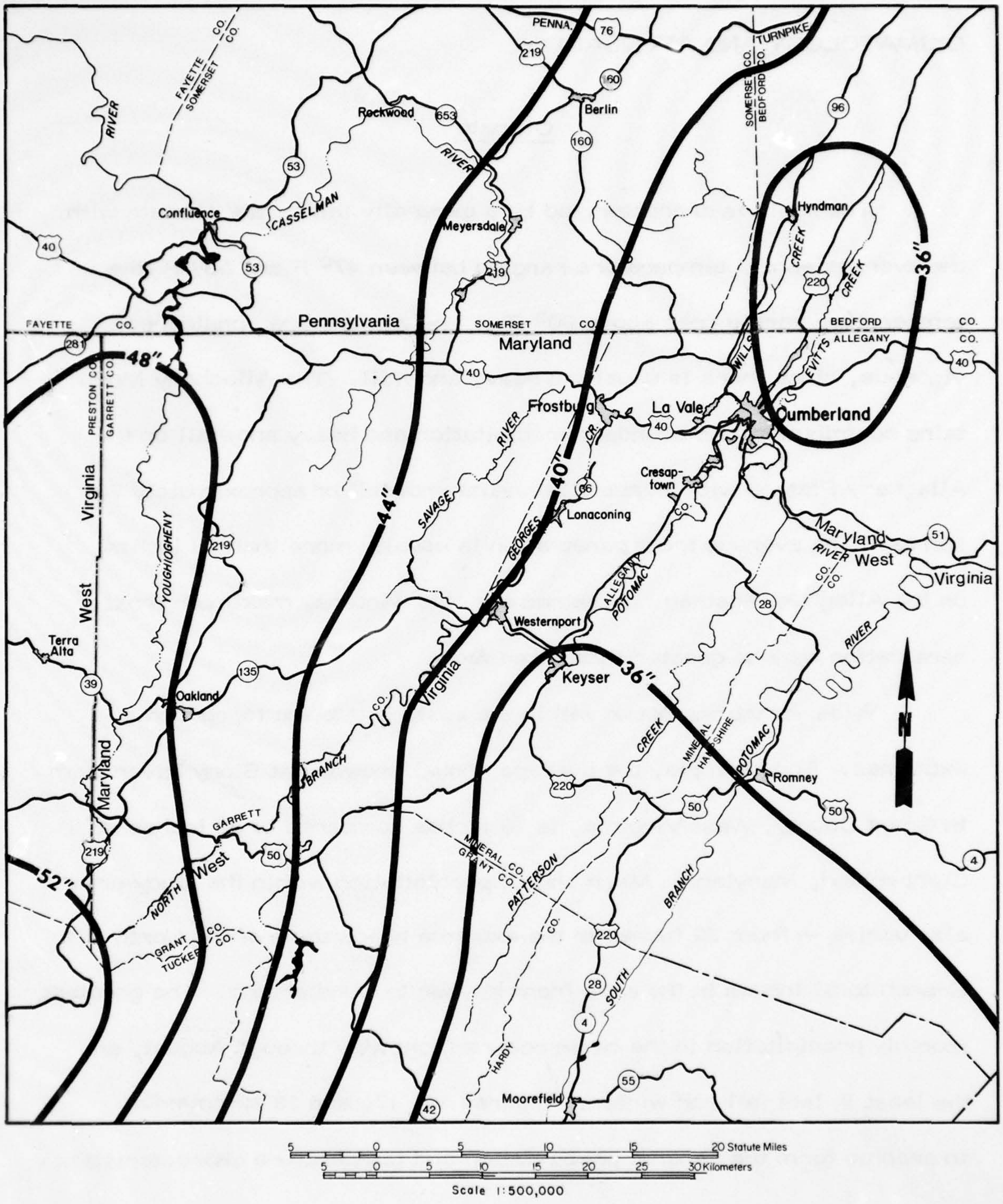
almost no natural alkalinity in the streams to neutralize even the smallest acid mine drainage discharges. Thus, both large and small acid discharges significantly impact stream quality, since those streams are unable to recover naturally from small concentrations of acidity.

CLIMATOLOGY AND AIR QUALITY

Climate

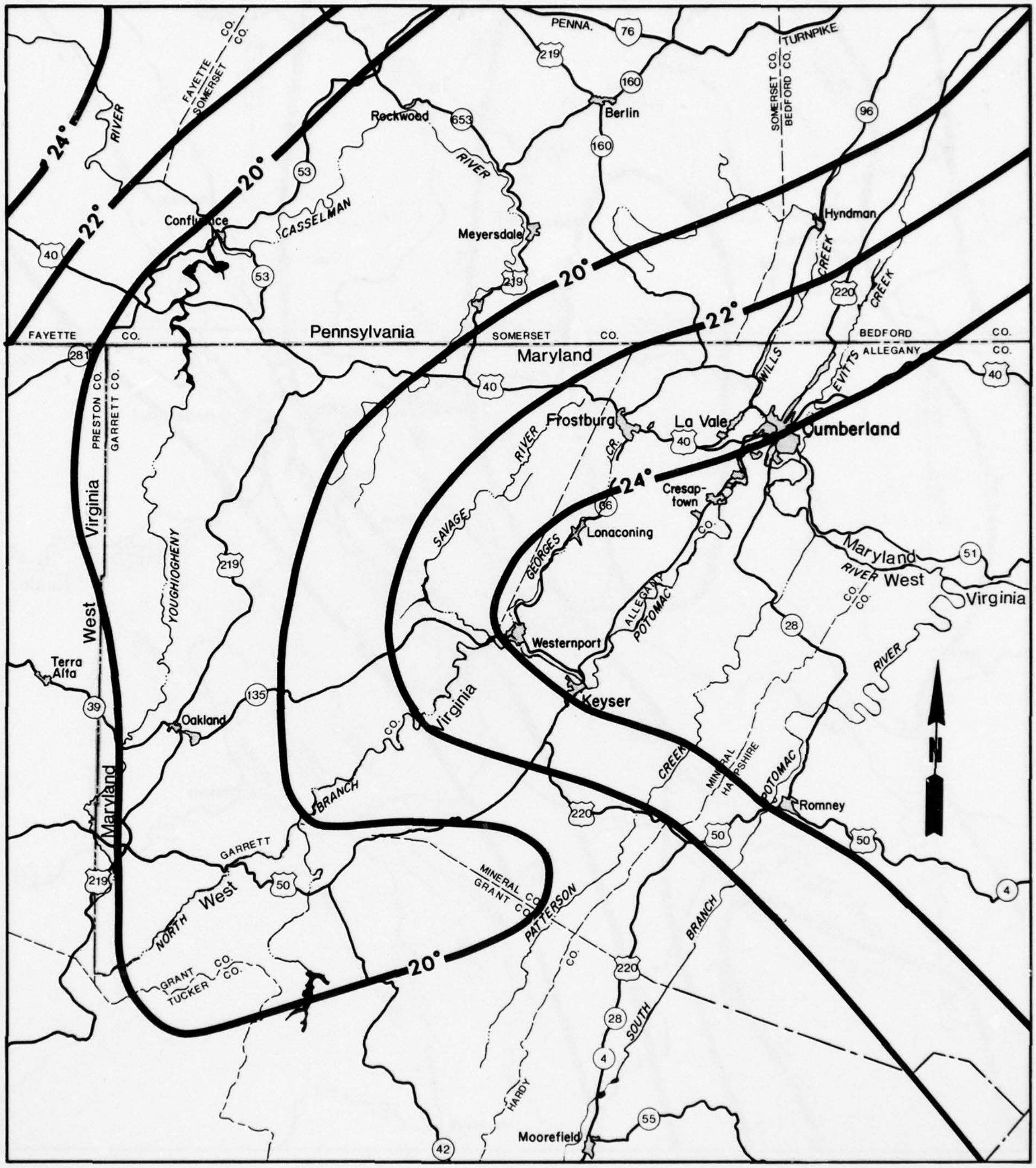
The basin is characterized by a generally temperate climate with the average annual temperature ranging between 47° F and 53° F (the temperature rarely goes above 90° F). The winters are considered vigorous, since there is usually a heavy snowfall. The Allegheny Mountains contribute to the abundant precipitation and heavy snowfall on the Allegheny Plateau with an average annual snowfall of approximately 70 inches. The average frost penetration is usually more than 18 inches on the Allegheny Plateau. In extremely cold winters, maximum frost penetration may be greater than three feet.

Wide variations occur within the basin due to the topographic extremes. For example, the average annual snowfall at Stony River Dam in Grant County, West Virginia, is 76 inches compared to 32 inches at Cumberland, Maryland. Mean annual precipitation within the study area also varies — from 52 inches in the extreme headwaters of the North Branch to 36 inches in the area from Keyser to Cumberland. The greatest monthly precipitation in the basin occurs from May through August, and the least in late fall and winter. Figures 16, 17, and 18 summarize in graphic form the general precipitation and temperature characteristics of the region.



MEAN ANNUAL PRECIPITATION (INCHES)

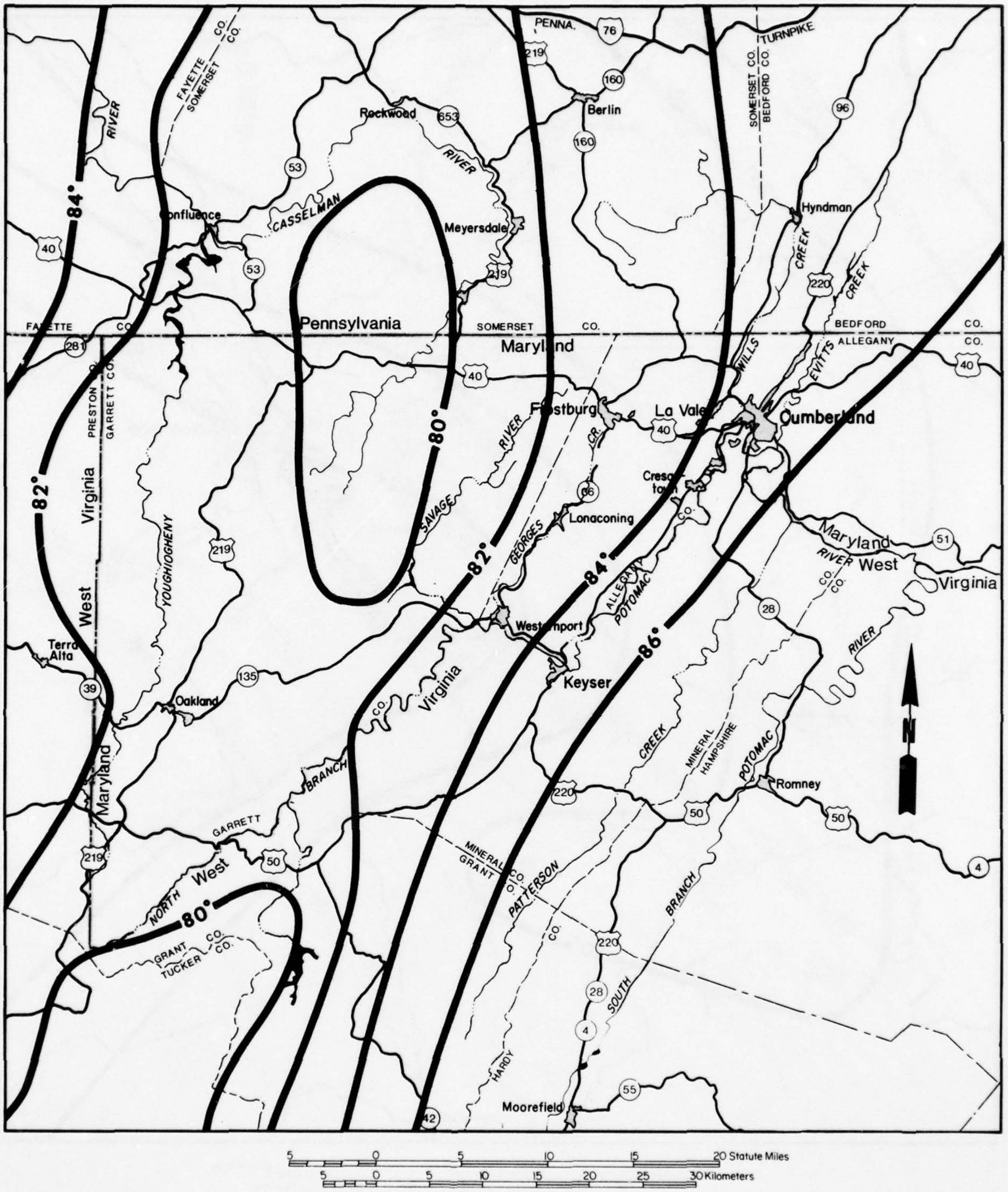
FIGURE 16



5 0 5 10 15 20 Statute Miles
5 0 5 10 15 20 25 30 Kilometers
Scale 1:500,000

MEAN MINIMUM TEMPERATURE (° F) JANUARY

FIGURE 17



MEAN MAXIMUM TEMPERATURE (°F) JULY

FIGURE 18

Air Quality

Data gathered from the Maryland Bureau of Air Quality for the most recent reporting year (1974) was summarized in the Task 3 Report for the following parameters: sulfur oxides, particulates, carbon monoxide, and nitrogen dioxide. The National and State standards for these parameters were also included in that Report. This data indicates that particulate matter in the study area presents quite a serious problem. The concentrations are generally very high in the city of Cumberland and decrease towards the western portions of the basin. This problem is most likely attributable to land development and highway construction and, to some extent, area surface mining operations which generate fugitive particulate matter. Under existing state and federal regulations, controls to reduce this type of pollutant are to be incorporated into both mining and industrial operations. Other parameters measured are well within the allowable limits.

MINING

One of the primary objectives of this study was an in-depth assessment of coal mining within the North Branch Potomac River Basin — existing conditions and potential future activities for both surface and underground mines. In conjunction with this, an assessment of active and abandoned surface and underground mining, involving delineation and classification of each minesite, was performed. The importance of distinguishing active from abandoned operations lies in the fact that abandoned surface and underground coal mines are the primary sources of sediment and acid mine drainage pollution throughout Appalachia. Abandoned underground mines alone are responsible for 75 to 90% of all mine drainage pollution discharged, with surface mines and refuse areas accounting for the remaining 10 to 25%.

Active operations should pose little or no threat of serious pollution, since their discharges must be in compliance with the State and Federal effluent guidelines and reclamation or mine closure regulations outlined in the Task 3 Report.

Effective January, 1977, both Maryland and West Virginia will be solely responsible for mine discharges within their boundaries. No untreated discharges will be allowed from closed underground mines.

Treatment must be in compliance with 1976 Federal coal industry effluent guidelines, which are summarized below:

Parameter	Existing Mines 1977	Existing Mines 1983	New Mines
pH	6.0-9.0	6.0-9.0	6.0-9.0
Net Alkalinity	Positive	Positive	Positive
Total Iron	3.5/7 ppm*	3/3.5 ppm	3/3.5 ppm
Dissolved Iron	0.3/0.6 ppm	0.3/0.6 ppm	0.3/0.6 ppm
Manganese	2/4 ppm	2/4 ppm	2/4 ppm
Total Suspended Solids	35/70 ppm	20/40 ppm	35/70 ppm

*1st digit = monthly average; 2nd digit = single day maximum

Existing mining conditions were assessed within the study area's coal field for several reasons: 1) to confirm for this specific area the previously mentioned generalities; 2) to locate and characterize all surface mines and the major underground mining areas (since these factors are very important in determining volumes and characteristics of drainage emanating from each area); and 3) to assess the future of the mining industry in the study area. Several aspects of the surface and underground mine identification and classification program and an assessment of the area's mining industry are discussed in the following pages.

Surface Mines

Aerial photography of the study area and subsequent delineation, reconnaissance, and classification of surface mined areas represent important aspects of this study; as such, their accuracy and usability played a major role in the accuracy and validity of final study recommendations. Vertical aerial photographs were exposed on a north-south axis over the center of each 7.5 minute USGS topographic quadrangle map in the study area. Photographic enlargements at 1:24,000 scale were prepared to correspond with existing USGS 7.5 Minute Quadrangle maps. It is important to note that the photos are not controlled mosaics, have no ground control, and do contain horizontal distortions due to the great vertical differences in elevation in the study area's mountainous terrain. However, actual use of the enlarged photographs both in the office and in the field reconnaissance program has shown that the distortions are relatively minimal, and do not present any significant problems.

Photo interpretive work on the 1:24,000 scale photographs was initiated with a careful scrutiny of each photograph in the office in conjunction with helicopter field reconnaissance. Helicopter aerial reconnaissance, rather than fixed-wing aircraft or stereographic techniques, was used exclusively in this study. The photo interpretive work was

conducted as a logical five stage effort:

- Close examination of each photo in office, and outlining of all apparent surface mining features as accurately as possible.

- Initial helicopter surveillance, delineation, classification of mined lands using the previously described classification system, and slide photography of each mine classified.

- Evaluation in office of data generated during helicopter surveillance, including examination of slides of each minesite and comparison of slide information with mapped data.

- Second and third aerial surveillance programs and subsequent office re-evaluations of data to fill any gaps left during the first helicopter surveillance.

- Limited, selected field auditing to assure accuracy of aerial evaluations.

These stages are discussed individually in the Task 2 Report.

The 1:24,000 scale photo overlays contain a great deal of study-related information, including:

- Surface mine locations and classifications
- Highwalls
- Stream sample locations
- Mine drainage discharge points
- Major basin and working watershed boundaries
- Deep mine entries, boundaries, refuse piles
- Major coal seam outcrops
- Special features such as Bloomington Lake's boundary

Each of these features is also discussed in detail in the Task 2 Report.

The surface mine classification system employed in this study, which is summarized in Table 3, consists of 2 levels — a series of 27

Table 3

SURFACE MINE CLASSIFICATION SYSTEM

Level I

Field and Map Classification System

A. Ungraded
B. Partially Regraded
C. Completely Regraded
D. Unvegetated (less than 40% cover)
E. Partially Revegetated (40–80% cover)
F. Completely Revegetated (greater than 80% cover)
G. Level Slope (less than 10°)
H. Moderate Slope ($10-20^{\circ}$)
I. Steep Slope (greater than 20°)

Level II

General Classification System for Reclamation Costing

1. Active
2. Completely Reclaimed
3. Minimal Reclamation Effort Required
4. Moderate Reclamation Effort Required
5. Extensive Reclamation Effort Required
6. Refuse

Classification Cross Index

Level I	Level II	Level I	Level II	Level I	Level II
ADG	4	BDG	3	CDG	3
ADH	5	BDH	4	CDH	3
ADI	5	BDI	5	CDI	3
AEG	4	BEG	3	CEG	3
AEH	5	BEH	4	CEH	3
AEI	5	BEI	4	CEI	3
AFG	3	BFG	3	CFG	2
AFH	3	BFH	3	CFH	2
AFI	4	BFI	3	CFI	2

characteristic classifications which will, for the purpose of computing reclamation costs, be summarized in a six category general mined land classification system. To simplify the classification task, a broad and easily definable classification system was developed based on the most critical characteristics of the unreclaimed surface mined land. The following factors were considered in this classification system:

- Extent of regrading completed after mining. This was broken down into ungraded, completely regraded, and partially regraded. Partially regraded here refers to areas in which regrading was only completed in portions of the mine or where only minimal regrading, such as spoil bank rounding, or any other poor reclamation work was done in compliance with older, less effective reclamation laws. Areas which have been satisfactorily regraded utilizing any conventional techniques were classified as completely regraded.

- Degree of revegetation of the spoil material. This is classified according to the amount of cover on the mine surface — unvegetated (less than 40% cover), partially revegetated (40% to 80% cover), and completely revegetated (greater than 80% cover).

- Angle of slope. This refers to the angle of slope as judged from the undisturbed land surface adjacent to the mined area. Categories for classification were steep (greater than 20°), moderate (10° to 20°), and level (less than 10°).

Each of these potential characteristic ratings for extent of regrading, amount of vegetation, and degree of slope was assigned a

letter designation. Thus, the mapped classification of each strip mined area involves a three-letter rating system — one letter representing each of these critical site characteristics.

This detailed field and map classification was keyed to a series of broad reclamation categories for use in final reclamation cost projections. Typical definitions of these broad classes, which were used for Task 4 projecting reclamation costs, are listed below:

Class 1 - This class consists exclusively of active strip mines, regardless of whether coal extraction or reclamation is in progress. Existing state surface mining rules require complete reclamation of all active surface mines by the operator, and are stringently enforced.

Class 2 - Class 2 strip mines have generally been satisfactorily reclaimed, minimizing or eliminating the need for application of additional reclamation costs.

Class 3 - These strip mines generally exhibit some degree of reclamation, whether by partial regrading and revegetation or by natural recovery of vegetative species on unreclaimed surface mines.

Class 4 - These strip mines will require a moderate reclamation effort, and generally represent the average condition of the coal field's unreclaimed strip mined lands.

Class 5 - This class represents strip mined lands in which an extensive reclamation effort will be required. Such strip mines are generally unregraded, and unvegetated, and located on steep slopes.

Class 6 – Surface mine reclamation techniques are also applied to refuse piles, which consist of waste materials from underground coal mines. This refuse is frequently much more toxic than strip mine spoil and as a result, is more difficult and costly to reclaim.

Underground Mines

Underground mine information was also plotted on the photomaps whenever it was available. The features mapped include deep mine entries and boundaries, refuse piles, and surface features of underground mine complexes. The primary deep mine emphasis at this level of study is directed toward identification of names and locations of the abandoned or inactive mines within each working watershed, rather than definition of specific mine boundaries. It is possible for this general level of study to approximate areas of deep mining based on the relative locations of drift mine entries along coal outcrops. For these reasons, relatively few specific mine boundaries were plotted on the photomaps. A summary tabulation has been developed which keys drift locations with name and coal seam mined. This deep mine tabulation was presented in the study's Task 3 Report.

ECOLOGY

The North Branch Potomac River Basin represents a region with a variety of forest, river and stream communities which reflect the region's diverse environmental conditions. Plant distribution is controlled primarily by the physical factors of the environment whereas animal distribution is more often determined by the types of food and shelter afforded by vegetation types. Elements which can influence aquatic populations can be physical and/or chemical. Physical factors such as amount of light, temperature, bottom substrate characteristics or water velocity can be limiting to normal abundance or diversity, while chemical parameters such as hydrogen ion imbalance, large amounts of heavy metals, and extremely high or low concentrations of normally essential substances can also exert significant influences.

Alterations to the natural environment can be categorized as man-induced or naturally occurring. Storms, fires, floods and other forces of nature have, throughout the centuries, served to alter the characteristics of the basin. Such changes manifest themselves in terms of wildlife abundance and distribution, watershed characteristics, soils properties and vegetative makeup. In the long run, however, these naturally occurring forces have a way of being absorbed by, and regulating, the natural environment.

By far, the most significant impact to the ecological system in the basin in recent time has been brought about by man. Mining, timber cutting and industrial or residential land development have altered the natural settings of the basin for over a century.

Surface and underground mining have been practiced throughout the area, regretfully for the most part, with little or no concern for protection of environmental quality. Poor conservation practices have led to often severe erosion and water quality problems with resulting impacts to vegetation and wildlife.

Lumbering operations, likewise, have in the past been conducted in such a manner that resultant damages are either irreversible or require decades for mitigation efforts to be effective.

Disruptions from industrial and residential land development, although not as severe as in more populated regions of the country, have also caused a change in the quality of the natural environment. Inadequately treated municipal and industrial wastes have traditionally served to degrade the quality of streams in the basin, and uncontrolled gaseous emissions from industrial operations have created air quality problems.

Fortunately, this historic trend of man-induced degradation is taking a turn for the better. Current regulations governing mining

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operations require that a number of pollution control measures be incorporated into the actual mining as well as post-operational land reclamation. Municipal and industrial effluents are regulated by both National Pollution Discharge Elimination System (NPDES) permitting procedures and by Bureau of Air Quality emission control strategies. Land development trends are carefully planned and monitored by counties and states which have plans to discourage uncontrolled development.

These measures are, for the most part, effectively controlling traditional environmental problems at the present and will hopefully continue to do so in the future. The problems associated with correcting past mistakes, however, are encompassed in an entirely different arena and must be viewed in terms of the desires and needs of those people affected by them as well as the costs and benefits associated with solving them.

Terrestrial Ecosystem

Surface mining and lumbering throughout the basin have had the principal deleterious effects upon the natural terrestrial ecosystem. These effects include: removal of vegetation and the resulting loss of the wildlife habitat, erosion, alteration of surface drainage, noise and dust from the actual operations, and habitat, erosion, and heavy truck

and rail traffic to and from the operations. Vegetation removal results in the loss of escape cover, winter cover, cover to rear young, and food and water. A lack of one or more of these cover requirements will normally cause a wildlife population to decline.

In nearly all soils the surface layer contains the main supply of organic matter which is the chief source of nitrogen and other necessary plant nutrients. With a removal of this essential topsoil, either directly or through erosive forces, the plant community will suffer, in turn affecting the animal population.

Flora

Forest lands cover nearly 60% of the North Branch Potomac Basin. The mixed mesic *deciduous forest* occupies the more humid, temperate low-lying valleys and consists primarily of beech, red maple and yellow poplar. This vegetative association extends to about 2,700 feet at which point the oak/chestnut forest type becomes predominant. Wild flowers found in the basin include jack-in-the-pulpit, violets, painted trillium and fireweed. Mountain laurel also covers many acres throughout the area.

The rich and diverse vegetative makeup of the basin provides

abundant food and cover for wildlife. All of the plant phyla (taxonomic groups), from the lower types such as algae and mosses to the higher groups or seed plants, are useful as wildlife food sources. The seed plants, with their two major subdivisions — conifers and broad leaf flowering plants — are by far the most important as both food and cover. In this group are all of the common trees, shrubs, vines, weeds, marsh plants and farm crops. Wildlife food sources found in the study area include: 1) fleshy fruits — grape, holly, blueberry, persimmon, sassafras, blackgum; 2) nuts — acorns, beechnuts, hazelnuts, pecans; 3) dry fruits from woody plants — maple keys, elm samaras; 4) seeds — pine, ragweed, crabgrass, bristlegrass, smartweed, deervetch; 5) vegetative parts of plants — clover, alfalfa, small herbaceous plants, tender spring shoots of woody plants; and 6) leaves, stems, and tubers of aquatic and marsh plants — pondweed, wildrice, widgeongrass, eelgrass, and maiads.

Fauna

The fauna of the North Branch Potomac River Basin is representative of the temperate deciduous forest biome. Three distinct layers supporting varied communities can be defined. The upper treetop or canopy supports an abundance of birds, invertebrates and small mammals. Lower-level tree communities — primarily maples — serve as habitat for

numerous birds and invertebrate species. The shrub-herb-grass community supports the majority of larger mammals, waterfowl and soil-dwelling invertebrates.

Due to the varied topography of the region, a large number of diversified habitats are available for bird life. The long valleys offer passageways and resting grounds to migratory species; the high ridges meet the nesting requirements of birds often considered more characteristic of northern climates; and the rivers, streams and ponds support abundant waterfowl.

Found primarily in the lower elevations are large flocks of common grackles, red-wings, blackbirds and cowbirds which are indicators of spring in the basin. Also found here in summer are the loggerhead shrike and the black vulture. Birds associated with the higher ridges of the study area include the golden-crowned kinglet, the magnolia warbler, Swainson's thrush, the veery, and the chestnut-sided warbler. Birds found near the area's rivers, streams, and ponds include the pied-billed grebe, black-crowned night heron, blue-winged teal, wood duck, lesser scamp, bufflehead, ruddy duck, hooded merganser, red-breasted merganser, and belted kingfisher. The most outstanding birds of the area are the wild turkey, golden eagle, and a variety of hawks.

At least 22 species of prominent mammals live in the North Branch Potomac River Basin. Of the larger mammals found in the area, the white-tailed deer is the prominent species. The common medium-size mammals in the area are the red squirrel, opossum, red fox, gray fox, snowshoe hare, eastern cottontail, star-nosed mole and raccoon. The largest carnivore present is the bobcat.

The basin is, likewise, the home of a diversified group of reptiles and amphibians. The many streams, ponds and wetlands in the lower-lying areas provide habitat for these organisms, but only if they are relatively undisturbed by influence from man.

Consultation with the Department of Interior's Office of Endangered Species reveals that there are no species of wildlife in the project area listed on the national register as being endangered. According to the Maryland Department of Natural Resources, however, there are seven animal species in the basin which have been determined to be "threatened with statewide extinction". These species are the bobcat, black bear, hellbender, jefferson salamander, green salamander, coal skink, and the mountain earth snake.

Aquatic Ecosystem

It is generally felt that monitoring of two critical biological parameters — the benthic macroinvertebrate community and the fish community — can adequately characterize the aquatic ecosystem and identify changes in environmental stress. These parameters are discussed in detail by stream reach under flora and fauna below, so that an assessment of fishery potential with improved water quality can be made during the evaluation stages of this project.

Flora

Although numerous biological studies have been conducted on the Potomac River Basin as a whole, these efforts unfortunately do not generally extend into the polluted North Branch watershed. The polluted portions of the basin are, for the most part, extremely limiting to vegetative growth.

While very little has been published on vascular aquatic plants located in rivers polluted by acid mine water, a recent related study has been conducted on the Monongahela River, just west of the North Branch in West Virginia. It can be inferred that this information is also applicable to the North Branch, which is comparable to the Monongahela in substrate, pH, iron, phosphate and nitrogen content. The

most abundant vascular aquatic plant found growing in acid waters was Eleocharis acidularis. Less abundant species included Sagittaria graminea, Sagittaria latifolia, Potomogeton ephihydrus, P. nodosus, Sparagenium americanun, and Myriophyllum heterophyllum. In this study, pH was determined to be nonlimiting for the species studied.

The micro-organism population of the North Branch Potomac River is also unstudied; but, based on studies in other areas, some acid tolerant species can be assumed to be present. These include iron oxidizing bacteria, blue-green algae, green algae, and some diatoms, yeast, and fungi.

Fauna

Fishery studies are of major importance and of primary public interest since fish are at the apex of the aquatic food chain and have sport and commercial value. Fish community structure and population size are intimately related to water quality and physical characteristics of the water body under consideration. Species composition, relative abundance and condition factors are influenced by stream depth, width, velocity, substrate, habitat cover, turbidity, temperature and chemical composition of the water.

In the study area, the parameter which most severely limits the

aquatic ecosystem is water chemistry. The stress caused by acid mine drainage in most of the North Branch is very severe. Many of the tributaries and segments of the main stream grossly polluted by acid have become "biological deserts", while other less-severely polluted reaches support only limited, low-diversity populations.

The most recent biological study conducted on the North Branch was performed by Davis (1973) of the University of Maryland Natural Resources Institute. Both fish and macroinvertebrates were collected at numerous locations throughout the watershed including the Potomac and Savage Rivers, Georges and Wills Creeks, and several smaller tributaries to the North Branch. Fish were absent from a number of stations and benthic fauna was sparse with low species diversity. No fish whatsoever were collected in the main stem of the Potomac from the headwaters to Luke, Maryland. The upper reaches of Trout Run supported a limited number of blacknose dace, creek chub and mottled sculpin. The benthic population in the stretch of river was likewise much reduced, with Trout Run and Lostland Run showing the only signs of a reasonably healthy bottom community.

Evidence of recovery to a healthy aquatic environment was not seen until the station near Oldtown, Maryland, just above the confluence with the South Branch Potomac River. Here some twenty species of fish

were sampled along with eleven orders of invertebrates.

Quite extensive sampling was also conducted on the major tributaries to the North Branch: Savage River, Georges Creek and Wills Creek. Savage River is considered polluted only below Aaron Run. The dam across the river has created a reservoir in which both warm water fish and trout are found. The brown and brook trout in the river above the dam occur naturally, with normal reproduction rates, while rainbow trout are stocked.

Georges Creek is degraded by acid mine drainage, but this problem is compounded by domestic sewage effluents throughout its length. The Davis study states that most of the macroinvertebrates found in the creek or its tributaries were insects, comprising from 40% to 100% of the fauna at each station sampled. Fish populations were limited throughout the length of the creek to blacknose dace, creek chub, white sucker, and mottled sculpin.

Wills Creek is intermittently affected by acid mine drainage and untreated domestic sewage. The main problem areas are the upper reaches of Jennings and Braddock Runs. Stretches of these streams which are unaffected by acid mine drainage support fish and benthic macroinvertebrates. In the cleaner stretches, as many as 21 species of fish are found along with 12 orders of invertebrates. The polluted tributaries, on the other hand, support no fish populations and limited benthic communities.

SOCIOECONOMIC PROFILE

Archaeological, Historic, and Aesthetic Resources

Numerous archaeological, historic, and aesthetic resources are associated with the area's history, spanning the periods of Indian occupancy, the French and Indian War, the Revolutionary War, Westward Expansion, and the Civil War. The frontier forts along the North Branch played active roles in fighting the French and their Indian allies for control of the upper Potomac and the Ohio River. Fort Ashby on Patterson Creek and the site of Fort Ohio near Cumberland are important historically. Elements of three important historical trade routes also exist in the area. They are the Cumberland Road (now U.S. Route 40), the Baltimore and Ohio Railroad, and the C & O Canal.

Within the basin, several sites, buildings and structures have been listed in the Federal Register of Historic Places as of February, 1973. They are:

- Allegany County, Maryland - Chesapeake and Ohio Canal National Historical Park; La Vale Tollgate House, U.S. 40; Oldtown, Michael Cresap House
- Mineral County, West Virginia - Fort Ashby

Other sites of historic, aesthetic or archaeological interest include the Nancy Hanks Memorial and Prospect Park in Mineral County; Smoke

Hole Caverns in Grant County; Backbone Mountain Scenic Overlook, Hayes Crest, and Crabtree Cove in Garrett County; the Narrows in Allegany County; and a number of Indian mound sites near Barnum, West Virginia and Folly Run.

Community Patterns

Population

Assessment of current population statistics can be very helpful in the prediction of future population trends. In general, population in the study area has remained relatively stable since 1960, following a decade in which a sharp decline in population levels took place. While the study area as a whole has remained stable, individual counties have shown significantly different patterns. Garrett, Grant, and Mineral Counties have exhibited population growth since 1960. Allegany County, however, has declined in population since 1950. The four counties in the study area all show high percentages of people over the age of 65, have low levels of persons who have moved into the area from out of the state, and have significantly high levels of out-migration. These tendencies toward population decline are countered by high fertility rates in three of the four counties. Allegany is the only county to have a low fertility rate. Thus,

the population gains experienced by Garrett, Grant and Mineral Counties are a result of high fertility rates compensating for out-migration.

Each county can be evaluated in terms of growth potential on the basis of the social characteristics considered above. Allegany County has the lowest growth potential with an unfavorable population distribution, high out-migration, and a low fertility rate. Garrett County has the highest potential relative to the other counties, with a high fertility rate and a high percentage of young persons in the county. The only factor favorable to growth in the West Virginia counties is high fertility rates. None of the counties exhibit strong trends toward a growing population.

Housing

The two more urbanized counties, Allegany and Mineral, tend to have similar statistical patterns, as do the more rural counties, Garrett and Grant. The rural nature of Garrett and Grant counties is evidenced by a relatively large number of farms in these counties. The rural counties have twice as many farms as the urban counties, while the urban counties have three times as many housing units.

The source of water is largely individual wells in rural areas and public or private systems in urban areas. The pattern for sewage disposal is similar to that for water supply; in rural areas individual systems dominate, while urban areas utilize sewage systems.

Land Use

Land use within the basin is determined by physiography. The eastern half of the basin is included in the Ridge and Valley Province, where severe topography limits development to narrow, northeast-southwest trending stream valleys. This section includes those portions of the basin east of Wills Mountain in Bedford County, Dans Mountain in Allegany County, and the Allegheny Front in Mineral and Grant Counties. Three linear strips of development exist in this area. The easternmost strip — located along Collier and Patterson Creeks — is primarily agricultural. The next line of development is the Evitts Creek valley, the foot of Knobbly Mountain, and the upper reaches of Cabin Run, which again are primarily agricultural. The last line of development encompasses most of the urban population in the basin — Cumberland, Bowling Green, Potomac Park, Cresaptown and Keyser along the North Branch Potomac River between Cumberland and Keyser, and the New Creek Valley. Agricultural lands lie between the urban concentrations and south of Keyser along New Creek.

The western half of the North Branch Potomac Basin lies in the Allegheny Plateau Province, a deeply dissected plateau which generally has flat, developable land in both stream valleys and upland areas. The study area is atypical of this, however, since it consists primarily of two

steep, narrow valleys. The first is defined by Wills Creek and Braddock Run, and includes three urban concentrations - La Vale, Ellerslie, and Hyndman - and some small farms.

Approximately 70 percent of the land in the basin is forested. A large local pulp and paper industry relies partially on these forests for pulpwood. However, much of the forest land is very steep or has been severely degraded by early logging and fire; this land is just now reaching commercial timber potential. For these reasons, timber production in the basin has been a minor economic activity in recent years; although current indications are that by 1990 there will be a significant upsurge in this industry.

Other significant land uses include agriculture - there are five major areas within the basin - and mining. Five major reservoirs located in the basin - Lake Koon and Lake Gordon on Evitts Creek, Stony River Reservoir and Mt. Storm Lake on Stony River, and Savage River Reservoir - serve water supply and flood control needs. A new multi-purpose reservoir - Bloomington Lake - is also being constructed on the North Branch Potomac River above Westernport.

Economic Structure

Economic Base

The economic base of the study area is comprised of four activities:

- Mining
- Agriculture
- Manufacturing
- Tourism

These activities provide income which originates outside the study area. The remainder of the economic activities within the study area can be viewed as support services which are built upon the economic base.

In terms of absolute numbers, manufacturing dominates the economic base of the study area. These industries are concentrated in the metropolitan areas, and produce a diverse set of products. The importance of four firms - Celanese, Hercules, Kelly Springfield, and Westvaco - surpasses all others. Fluctuations in the regional and national demand for their products would lead to serious fluctuations in the general economy of the study area.

The three remaining economic base activities all show differing growth trends. Among these activities, mining exhibits the strongest growth trend. This strength is most apparent in Grant County, which produces more coal than the other three counties combined. In 1971,

Grant County produced $14.26 million of coal, Garrett County produced $7.95 million, Allegany County produced $2.29 million, and Mineral County produced $2.05 million (Corps of Engineers, 1975). The employment trend indicates that the specialization of Grant County in the production of coal should continue. A surge in Garrett County's coal production is also forthcoming in the near future.

Agricultural employment declined in all four counties. In absolute terms, the drop was greatest in Garrett County, which has the largest agricultural sector. The trends toward fewer farms and lower agricultural employment should continue proportionally in all counties; therefore, Garrett County's dominance in the agricultural sector will remain.

Employment related to tourism is significant in only Allegany and Garrett Counties. Tourist expenditures tend to be seasonal and tourists often use facilities patronized by local persons. Transient facilities serve tourists who are traveling through the area. These facilities rely heavily on visibility to draw customers and thus are located adjacent to major transportation facilities. In Allegany and Garrett Counties, most of these establishments are located along Route 40, which is primarily a full access route with small stretches of limited access.

The other types of tourist expenditures (related to water and snow

sports, and normal consumer purchases) originate from persons who are staying a number of days to take advantage of local recreational resources. The greatest impact from this type of expenditure is associated with second home development. More than 75 percent of the second homes in Western Maryland are located at Deep Creek Lake. Other sites tend to be located along the North Branch Potomac River.

In summary, it can be seen that regional specialization in economic base activities has occurred within the study area. Manufacturing activities are located mainly in Allegany County with the corresponding labor force residing both in Allegany and Mineral Counties. Land intensive natural resource activities, agriculture and mining, tend to be located in Garrett and Grant Counties; Grant County specializes in mining with a lesser degree of effort in agriculture, and Garrett County specializes in agriculture with a lesser degree of effort in mining. Tourist activities are concentrated in Garrett County.

Employment

Three employment-related variables were examined in Task 3 - employment, payroll, and number of firms. Allegany County has a large percentage of its employment in manufacturing activities. Average wage rates are relatively high (greater than $8,000 per year) in manufacturing, mining, construction, and transportation/public utilities.

Garrett County has a high level of employment in retail trade. Wage rates are high in mining, construction, and transportation/utilities. *Wages are low (less than $4,000 per year on average) in the service sector.*

Despite disclosure limitations in Grant County, previous discussions indicated high levels of employment in mining and construction activities. These high levels of employment are surprising when compared with the very few number of firms in these two activities. High wage rates are indicated in the transportation/utilities, wholesale trade, mining, and construction sectors. Low wages are apparent in the service sector.

The data examined for Mineral County indicates a large portion of the employment in the county was in the service sector. This statistic reinforces the picture of Mineral County as a residential area for the industrial employees who work in Allegany County. High wage rates are noted in the service, mining, and construction sectors. The retail trade sector has low wage rates.

Certain area-wide trends can be found in the specific analysis presented above.

- Wage rates are high in mining, construction, manufacturing, and transportation/utilities, relative to other economic activities in the region.

- Certain activities have become highly developed in specific counties due to regional specialization: manufacturing in Allegany County, retail trade in Garrett County, mining and construction in Grant County, and the service sector in Mineral County.

- Large firms are the exception, not the rule; they exist only in manufacturing in Allegany County, and mining and construction in Grant County.

These trends are important in determining the future economic structure of the study area. For example, growth in high wage activities would lead to a greater level of wealth in the community, while growth in low wage activities would lead to lower average income levels. Also, dependence on a single economic activity or a few large firms would create a situation where the local economy was highly sensitive to the national business cycle.

Within the study area, the greatest opportunity for income growth is found in the mining sector. Grant County is in the best position to take advantage of this growth opportunity. Allegany and Mineral Counties are the most sensitive to the business cycle, due to the dependence of their local labor force on large manufacturing firms. In a similar fashion, the growth potential in Grant County could be jeopardized by its dependence on a few large coal firms.

Income

Median income levels for each county indicate the importance of manufacturing in generating high income levels. The ordering of the counties with regard to income levels follows the ordering of their dependence on manufacturing employment. In no case, however, does any county income level come close to the median income level for Maryland. This statistic points to the high level of poverty in the study area.

The income distribution in the area is also reflective of the high, long term unemployment in the area. All the counties in the study area have been designated as areas having substantial or persistent unemployment by the Manpower Administration, U.S. Department of Labor. These depressed conditions are typical of Appalachia.

Infrastructure

Transportation

Rugged topography and frequent snowstorms have severely hampered the development of the study area's transportation to its fullest potential. Currently, U.S. Route 40, a two-lane facility, is the only major road crossing Allegany County east-west; U.S. Route 220 and Maryland Route

36 - both two-lane highways - cross the county north-south.

The National Freeway (currently under construction as a part of the Appalachian Highway Program) crosses both Allegany and Garrett Counties in an east-west fashion. When completed, it will be a limited access, four-lane highway linking the Baltimore-Washington area to Cincinnati.

In the Garrett County portion of the basin, the primary road network is two-lane, undivided, and of unlimited access. The major roads in Grant and Mineral Counties are similar. These conditions make these areas undesirable in terms of supporting appreciable increases in recreational and commercial loads.

The secondary or feeder network provides the principal source of access to most of the rural and developing portions of the area. Typically, this secondary network is in need of substantial improvement. The primary reason for these inferior conditions is a lack of systematic maintenance and construction programs, rugged weather and topographic conditions, and in part increased traffic, accelerating the deterioration of older and/or more poorly constructed roads.

Other modes of transportation in the area include rail and air service. Railroads are utilized by industry for freight service, while air service is oriented toward personal service and pleasure flying.

Cumberland, Maryland in Allegany County is the Western division headquarters for the C&O/B&O Railroad and the Western Maryland Railway. In West Virginia, rail service is confined to the northern region (Mineral County) along the North Branch Potomac River. A freight spur extends into Petersburg (Grant County). This spur is essential to the economy of the entire surrounding area (Hampshire, Hardy, Grant and Pendleton Counties).

Air service into the study area is severely limited. Cumberland Municipal Airport is the major air traffic center - accommodating more than 17,000 operations per year.

Water and Sewer

Water and sewer facilities within the basin are currently limited to those areas with significant urban populations. Because these urban concentrations are limited topographically to narrow river valleys, there are serious problems with regard to adequate water supplies and sewage treatment.

Presently, there are municipal water and sewage systems for Cumberland, Frostburg, Keyser, and Westernport. Cumberland is the only community in the basin that provides secondary waste treatment. Water service only is available in a number of basin communities -

Lonaconing, Midland, and Barton in Allegany County; Bloomington, Kitzmiller/Shallmer in Garrett County; Bayard in Grant County; and Piedmont, Wiley Ford, Fort Ashby, and Elk Garden in Mineral County.

The major industrial river water users are located on the North Branch Potomac River between Luke and Cumberland. They include Westvaco Corporation (60 MGD), Potomac Edison Company, Celanese Corporation, and Kelly-Springfield Tire Company (combined 77 MGD).

PREDICTION OF FUTURE CONDITIONS

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PREDICTION OF FUTURE CONDITIONS

RANGE OF POSSIBLE FUTURES

In evaluating potential future conditions for a given region, three general categories or trends must be defined. These range from full rapid growth and development, to a continuation of historic growth patterns, to a decline or cessation of growth. In attempting to place the growth future of a region into one of the three general categories, both of these sets of conditions must be evaluated.

The first set of conditions is indicative of urban growth potential and essentially defines the attractiveness or potential of an area to expand. It includes such factors as accessibility, quality and quantity of labor, availability of natural resources or raw materials, public and private services and other amenities. Since the ability to furnish these factors is not equal among regions, some areas will have greater inherent economic growth potential than others.

The second set of conditions is more subjective or variable in nature and may serve to equalize the shortcomings of a region lacking some of the amenities discussed above. These conditions are more controllable in that they are established by man. They are the plans, desires, and aspirations of the people of the region, and are frequently expressed in terms of master plans, legislation or public involvement activities.

In spite of the inherent shortcomings to economic development

potential in the North Branch Potomac River Basin, the future of the area is not as dim as it may initially appear. As stated earlier, the goals, aspirations, and plans of man can serve to significantly offset some of these obstacles. The counties and regions of the study area have formulated comprehensive master plans which recognize development problems, define goals and objectives, and plan strategies for accomplishing these goals.

The Garrett County Development Plan is predicated on the concept of carefully controlled urban development densities and on preservation and better utilization of open space lands. The Plan makes provision for varying density levels, while making explicit the need to concentrate high density development in a number of compact community centers which are endowed with necessary urban services (especially water and sewer).

The Plan proposes that additional industrial lands be provided in a few prime, selected sites or "employment centers", designed exclusively for industrial uses. It was concluded that these sites should constitute the most developable land in the county. They should be fairly limited or compact in extent; they should be totally isolated from incompatible uses; and they should be in public ownership, if at all possible.

Allegany County's primary development objective is the improvement of the quality of life. This is to be achieved through development of the county's latent economic potentials by reserving a generous supply of

industrial sites which are suitably located with regard to topography and access and which have necessary urban services; and by protecting and developing the scenic, recreational, open space, and historical resources of Allegany County with the aim of increasing their economic value. A second county objective is improvement of services in existing development areas, as well as providing facilities to accommodate new development, and guiding the location and density of such development in a manner consistent with conservation of land and natural resources and efficient delivery of urban services. The Plan also recommends that prime development lands in the county first be considered for industrial uses, since such lands are scarce. These lands should be developed as industrial park complexes, provided with modern access roads and public water and sewer facilities.

Finally, the Plan recommends the preservation of state forest lands and wildlife management areas. New extensive recreation areas proposed include: Dans Mountain Park, the Narrows Park, the C&O Canal Park, Town Creek Reservoir/Park, Town Hill Mountain Park, and Irons Mountain Park. Sixteen new community parks and expansion of five existing school playgrounds are also recommended. Lastly, the preservation of historical sites and structures is recommended.

The West Virginia Region 8 Planning and Development Council is responsible for the planning activities for Grant, Hampshire, Hardy,

Mineral and Pendleton Counties in eastern West Virginia. The Council is divided into a number of committees with areas of concern ranging from industrial development to preservation and enhancement of natural and aesthetic resources. Although the Region currently does not have zoning or land use controls in effect, the Council has established policy on needs and goals and developed preliminary strategy for implementation.

General land use policies are to conserve prime agricultural land and provide for orderly transition from rural to urban land use where appropriate, and to ensure that development is commensurate with the physical and environmental character of the land. Other principal efforts are aimed at developing the region's forest and woodland potential for forestry industry, conservation and aesthetics, and establishing floodway protection. This is being accomplished through riverbank stabilization activities and resource studies in the region.

The development of a comprehensive recreation and tourist program and associated supportive services has also been recommended. Problems currently facing this effort include a lack of effort to promote a tourist trade, limited water-based recreational areas, inaccessibility of the area to tourists, and a lack of supportive services such as hotels and restaurants.

LIMITING THE RANGE OF PROBABLE FUTURES

Based on an understanding of the non-variable conditions of the study area (topography, raw materials, etc.) and the variable conditions (land use plans, strategies, goals) one can begin to narrow the range of possible future growth patterns to a more finite scope.

An economic downturn in the Appalachian economy is highly unlikely because of the increasing importance of coal to the national economy. Coal will remain important over the term of this analysis both because of political policies designed to make the nation independent of foreign energy supplies and because the coal reserves are sufficient to supply a significant portion of national demands over this time period. Coal mining will provide a stable base for the Appalachian economy, acting as a limiting factor to any recessionary influences.

A rapid economic boom is unlikely for the same reasons that have historically retarded economic growth in the region. High transportation costs and the lack of social infrastructural needs will continue to block the parity of the Appalachian economy with the national economy. Also, the expansion of local incomes from increased activities in coal mining and tourism will be directed toward the chronically unemployed resources (labor and capital) currently available in the region; thus, immigration of people and capital in large numbers is not likely. For these reasons,

the range of possible futures does not include the overly rapid development of Appalachian economy.

Perhaps the most authoritative analysis of the economics of the Upper Potomac Basin has been presented by Professor William H. Miernyk, economist and director of the West Virginia Regional Research Institute. The Regional Research Institute has been involved, since 1965, in the study of the interrelated forces which drive the economic development of the Appalachian Region.

If the future projected by the technological optimists should be realized, market forces would dictate a substantial increase in the recreational and residential development of the entire area. The region would become a recreational "playground" for the affluent. Land values would increase and rising personal income would further skyrocket the economy. Economic growth based solely on this type of activity, however, has its undesirable side-effects. In an effort to preserve the bucolic nature of the area, the manufacturing and industrial sectors of the economy would be discouraged. This industrial development is essential to the balanced and secure economy of the area.

If the pessimists are correct, the long-run future of the Upper Potomac will probably be one of uncontrolled drift. With the national shortage of energy-producing fuels, the coal resources of the basin will become more attractive and short term economic boom will ultimately yield to the typical depression characteristic of southern Appalachia a decade ago.

In conclusion, Professor Miernyk supports his case as an admitted "confirmed eclectic" by stating:

> "On balance, the Upper Potomac River Basin probably has a more promising economic future than many other regions of the nation. It is well-located with respect to major urban areas, it is a producer (albeit on a small scale) of energy, and it should benefit from the spillover effects which are likely to result in income shifts from energy consuming to energy producing states. It is a region abundantly endowed with areas of great natural beauty, and its topography will ensure limits to urbanization.
>
> Historically, the Upper Potomac River Basin has lagged behind the nation in terms of economic development. In 1960, for example, median income in the Basin was 30 percent less than the national average. By 1970, this differential had been cut in half; median income was only 15 percent below the national average. Even if one agrees that there are some difficult times ahead, there should be continued improvement in the Basin relative to the nation. It is not at all unlikely that by 1980 — or certainly by 1990 — median income in the Basin will equal or perhaps slightly exceed that of the nation. There is nothing on the horizon to suggest a major economic boom in the Upper Potomac River Basin. But the combination of good location, resource base, and improving transportation facilities <u>support the projection of slow but steady progress in the Basin for the rest of this century</u>."

DESCRIPTION OF "MOST PROBABLE" FUTURE

Socioeconomic

Baseline socioeconomic projections were developed on the basis of historical trends. Multiple regression techniques provided the method for projecting the future economic base employment from these trends. Total employment, population, and housing units were computed on the basis of the projected economic base employment levels. Detailed projections were developed for each county to the year 1990. A more general range of population projections were also presented for year 2020 on the basis of three different methods:

- An extrapolation of the economic base projection;
- An extrapolation of Maryland State Planning projections;
- OBERS projections.

Allegany County is the only county exhibiting a decline in population and employment. The only economic activity showing significant growth is tourism. Both recreational and transient-related tourist facilities should expand with recreational facilities developing adjacent to Rocky Gap State Park and transient facilities expanding in conjunction with interchanges along the National Highway.

Garrett County exhibits the largest growth among the four counties. Only agricultural employment declines in the county. The rapid growth

is largely a result of gains in manufacturing and tourism due largely to the completion of the National Highway. Coal mining activities will also expand significantlyas coal becomes more important to the national economy.

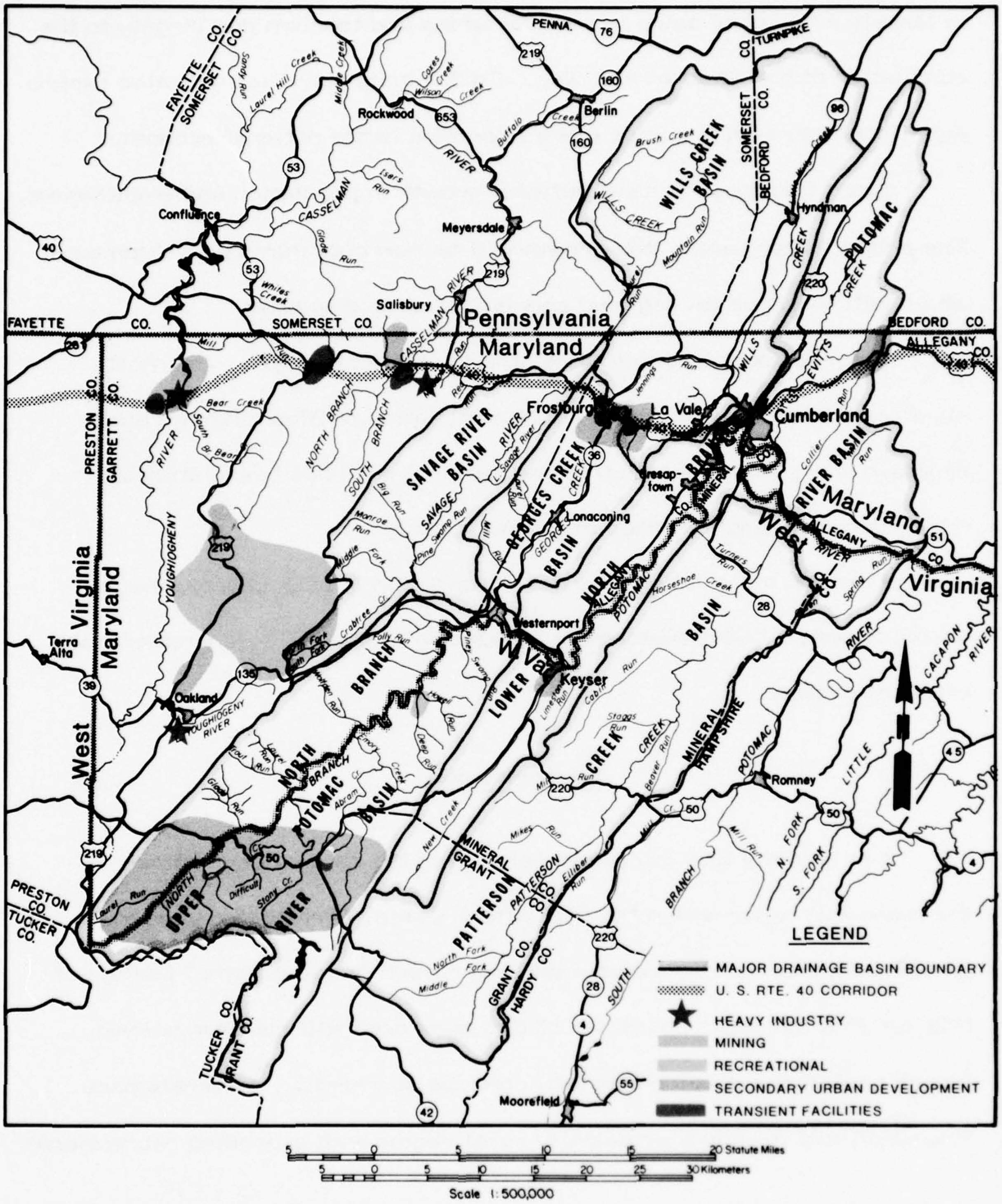
Grant County exhibits significant growth in population and employment. The prime factor behind this growth will be new coal mining developments, which will increase its regional specialization in this area.

Mineral County exhibits a relatively stable situation. The most significant change will occur with the completion of Bloomington Lake. Employment associated with this recreational area has been estimated from corresponding facilities in Garrett County.

Based on the existing land use distribution in each county, the following figure, "1990 Development Prediction", shows the general areas of expected growth.

Environmental

It is unlikely that any drastic change in the natural environment of the basin will occur within the next fifteen years. Predicated upon the growth patterns and rates discussed under the "Socioeconomic" portion of this section, the basic character of the study area will not change even though growth and development will continue at a steady, moderate pace. The basin will remain a principally rural region with expanding recreational



1990 DEVELOPMENT PREDICTION BASED ON EMPLOYMENT TRENDS

FIGURE 19

and industrial centers attracting the majority of new population, employment, and services. The economic base of the region will continue to rest upon manufacturing, tourism and, to an increasing extent, mining.

In evaluating the future environmental character of a relatively undeveloped area such as the North Branch Potomac Basin, one must be careful not to assume that environmental degradation, so often associated with industrial and residential expansion in the past, will continue to be the rule. On the contrary, the concerns of federal, state and local administrations with environmental protection and enhancement will place tighter restraints and controls on the historic causes of this degradation. The future environmental character of the region will, therefore, manifest itself as a combination of the past environmental mistakes existing in the area with the future efforts towards environmental enhancement. This trend will tend to be most apparent in the air quality, water quality and terrestrial environment of the region.

Air Quality

Particulate problems evident in the study area are thought to be related primarily to fugitive dust generation from land development, construction and demolition activities, and past and present surface mining operations. It is probable, however, that increasingly stringent controls

over activities which contribute to air quality degradation will be enforced. This should serve to limit further degradation of new source emissions in the region. The abandoned surface mines, if left unreclaimed, however, will continue to create problems. Should an alternative for this study be selected which incorporates reclamation and revegetation of abandoned surface mines, an improvement in air quality would very likely be realized.

Chemical Water Quality

The various chemical water quality complexities of the North Branch Potomac River Basin and their bearing on near-future stream conditions were discussed in the Surface Water segment of the Hydrology Base Conditions. In fact, a computer simulation of near-future base conditions, incorporating Bloomington Lake and the progressing clean-up by the basin's active mining operations, was developed and utilized as a base upon which to model the impacts of proposed abatement alternatives. This Projected Base Conditions with Bloomington Lake simulation — which encompasses net alkalinity and pH for both mean flow and seven-day ten-year low flow is discussed on pages 54 through 70, and illustrated graphically in Figures 10, 11, 12, and 13 within those pages.

With the exception of any abatement activities performed as a result of this Phase I or subsequent Phase II studies, no further significant changes in Potomac Basin water quality are anticipated in the foreseeable future. All currently active mines and all new mines opened in the future will have to be in compliance with state and federal effluent guidelines. The remainder of the basin's acid mine drainage problems are attributed to abandoned surface and underground mines, and without positive remedial action, those problems will not change significantly. Thus, future water quality within the basin is expected to approximate that shown in the Projected Base Conditions with Bloomington Lake.

Aquatic Ecology

The "no-project" future of the North Branch Potomac River is essentially a projection of existing conditions but includes the completion of the Bloomington Lake. The high acid levels of the North Branch from the headwaters to around Spring Gap, Maryland, completely prohibit either a natural or managed fishery. It is not until the vicinity of Oldtown, Maryland, at the confluence of the South Branch Potomac River that recovery to a normal aquatic habitat is realized.

Although the physical and chemical properties of the North Branch could possibly support marginal populations of acid tolerant organisms,

the "acid slugs" resulting from wash-outs upstream negate the possibility of permanent colonization.

Terrestrial Ecology

The economic base projections discussed in the earlier section of this report indicate a significant increase in mining activity throughout the basin for the next 15 years. Although mining in Allegany County is expected to decrease, the increases in the remainder of the basin are projected at: Garrett County $\pm$ 324%, Grant County $\pm$ 179%, and Mineral County $\pm$ 55%. This mining activity will, however, be taking place under the control of new reclamation requirements and should not have the long-lasting derogatory effects traditionally associated with surface mining.

The tourist industry in the region, likewise, is projected to increase drastically. Baseline economic projections show a 143% increase in the tourist business for Garrett County and a 111% increase for Allegany County for the year 1990. The recreational usage of land may be considered quite diametrically opposed to the use of land for surface mining operations. For this reason, it may be assumed that these two sectors will, in effect, segregate themselves into respective portions of the basin. The 1990 Development Prediction map (Figure 19) illustrates this point.

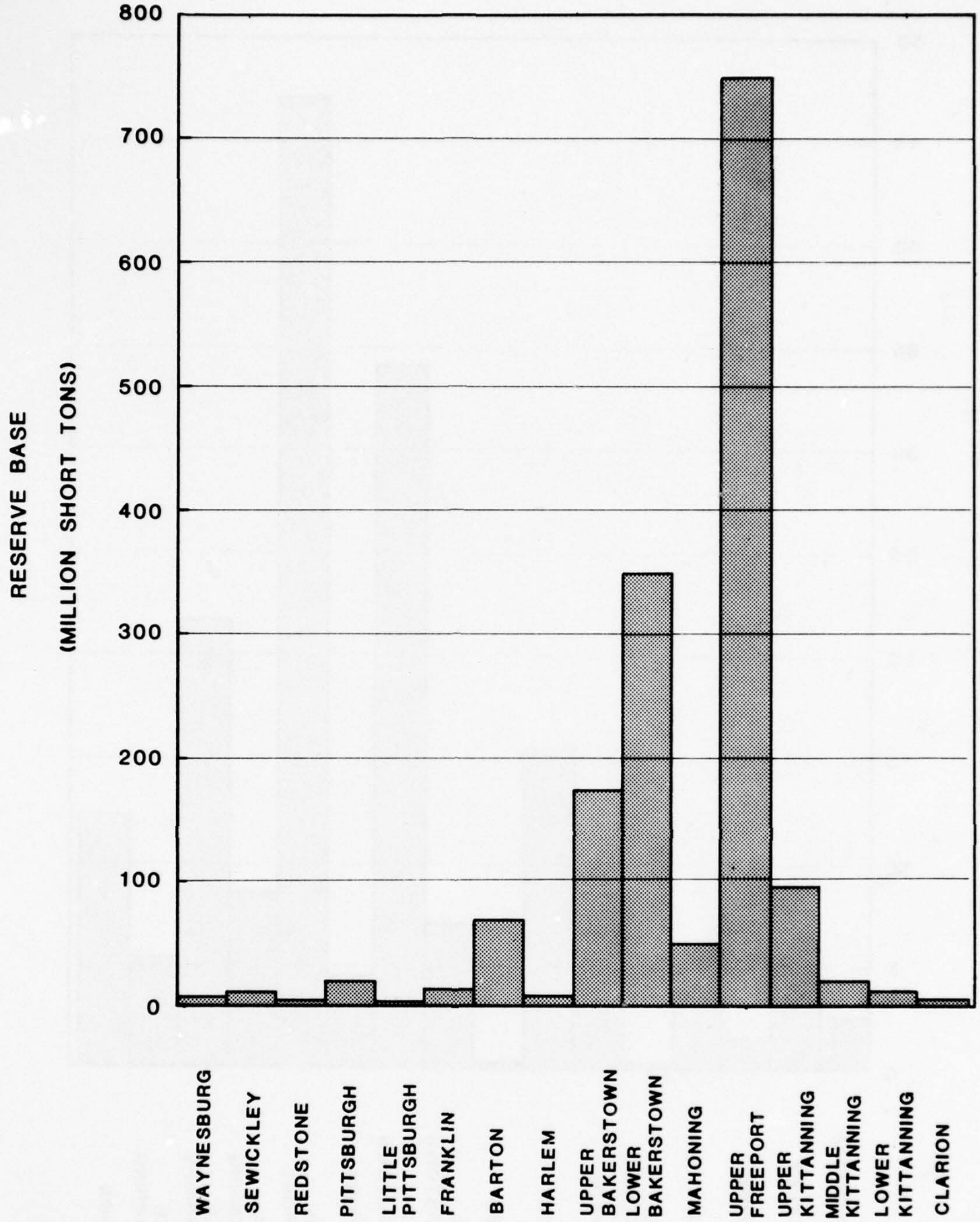
The "do-nothing" alternative future for this terrestrial environment of the study area, in summary, is essentially a continuation of existing conditions within the basin itself, with continuing land development for mining and recreational facilities at specific locations throughout the region.

Future Mining Potential

The coal mining industry — past, present, and future — was analyzed in some detail in the Task 1 Report. The conclusions presented in that report are summarized here:

- Total coal production and surface mine coal production have been rising almost steadily in the past 23 years, and should continue to rise in the future.
- Underground coal mining, which has shown a steady decline except for Island Creek Coal Company's two West Virginia operations, should begin an upswing in the near future with the announced openings of two new underground mines by Island Creek and Mapco.
- Major coal producing seams in 1974 were the Upper Freeport, Pittsburgh, Sewickley, Barton, and Lower Bakerstown.
- Study area coal reserves total 1.6 billion tons; strippable reserves (based on 1971 economics) total 176 million tons (see Figures 20 and 21).
- Major low-sulfur (less than 1.5%) strippable reserves are found in the Upper Freeport, Barton, Lower Bakerstown, and Sewickley seams.
- BTU values of all study area coal seams are exceptionally high for Appalachia.

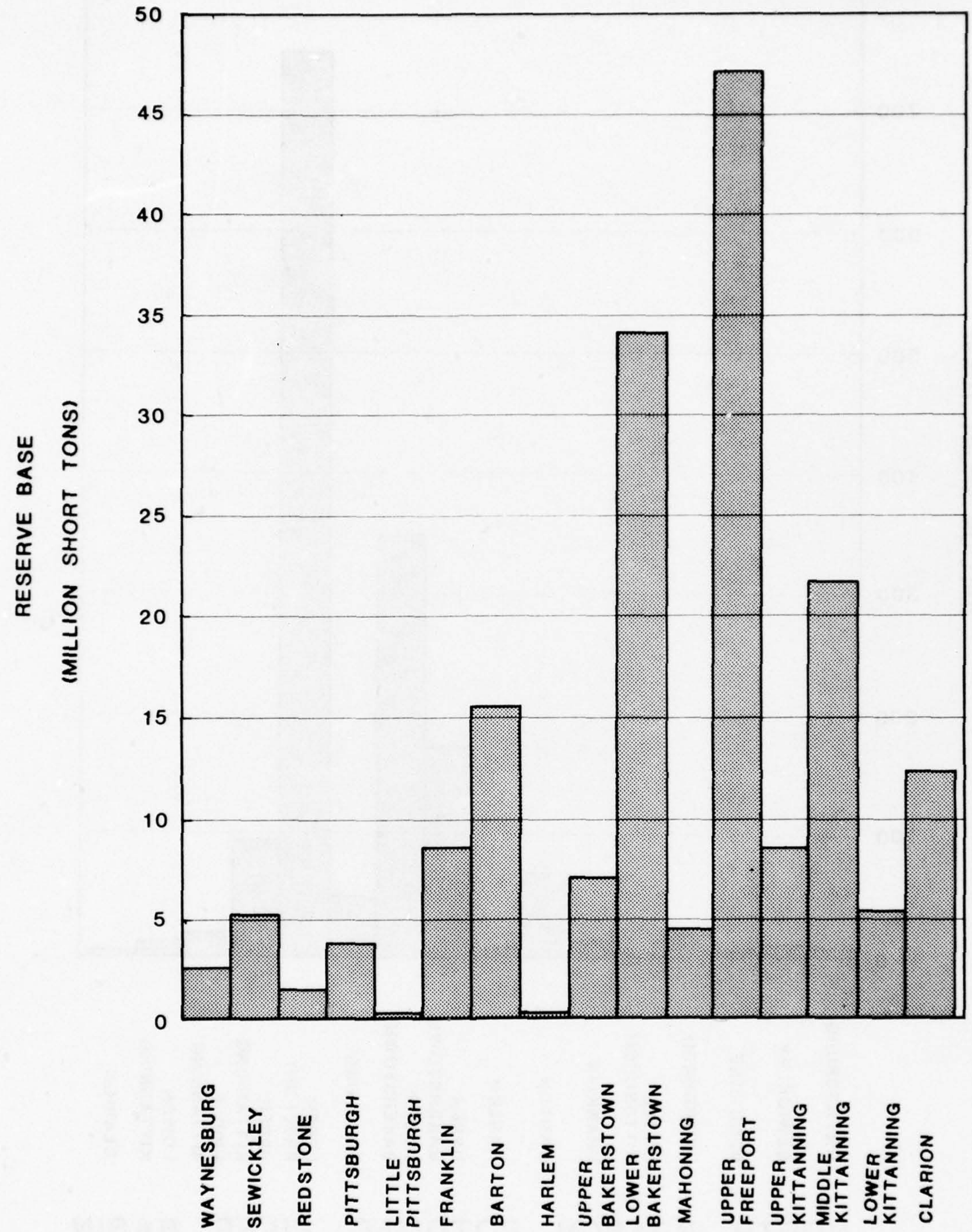
Based upon these points, it appears that surface mining in the North Branch Potomac Watershed will flourish and continue to expand in the near future as the demand for coal, inspired by the energy crisis, spirals upward. Seams with the greatest potential for future surface mine coal production are the Upper Freeport, Barton, Lower Bakerstown, and Sewickley, all of which have large, strippable reserves of low sulfur coal. This expansion of surface mining in these seams will undoubtedly affect existing abandoned surface mined lands. As underground mining technology advances, it is felt that this aspect of the coal industry will again expand to play a major role in the coal production and economics of the study area. The initial step in this forecast expansion is already being taken, as mentioned above. With increased underground mining, the bulk of coal production might be expected from the Upper Freeport, Lower Bakerstown, Upper Bakerstown, Upper Kittanning and Barton seams. In either case, it appears that, in future years, mining will gradually swing away from the Pittsburgh and Sewickley seams, because they have already been extensively mined out in the Georges Creek Basin and are absent in many portions of the basin further south. Thus, it appears that the Upper Potomac and Georges Creek Coal basins will continue to expand and meet the needs of our growing energy demands both in the immediate and distant future.



NORTH BRANCH POTOMAC RIVER BASIN
TOTAL COAL RESERVE BASE BY SEAM

MARYLAND AND WEST VIRGINIA

FIGURE 20



NORTH BRANCH POTOMAC RIVER BASIN
STRIPPABLE COAL RESERVE BASE BY SEAM
MARYLAND AND WEST VIRGINIA

FIGURE 21

DEVELOPMENT AND ASSESSMENT OF ALTERNATIVE RECLAMATION AND ABATEMENT PLANS

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DEVELOPMENT AND ASSESSMENT OF ALTERNATIVE RECLAMATION AND ABATEMENT PLANS

EVALUATION OF RECLAMATION AND ABATEMENT POTENTIAL

A number of preliminary considerations regarding mined land reclamation and mine drainage abatement were made prior to the actual formulation and assessment of abatement plans or alternatives. These considerations included: 1) an evaluation of available abatement measures and their relevance to project objectives; 2) the development of typical or average reclamation costs for use in subsequent abatement alternative assessment activities; and 3) quantification of the typical or average impacts of various reclamation and abatement activities. Detailed discussions of these tasks were included in the Task 4 Report, and brief summaries of the activities and findings are presented in the following pages.

Available Technology

A wide range of acid mine drainage abatement measures were analyzed during Task 4 as they relate to economic and environmental goals. All abatement measures and techniques in the October, 1973, EPA manual "Processes, Procedures, and Mthods to Reduce

Pollution from Mining Activities", which is considered by many to be the most comprehensive state-of-the-art pollution control manual available, were screened for use in the basin as appropriate. Those measures which were determined to be inappropriate, either because they could not be applied to the types of mining techniques found in the basin or because they are not currently technologically or economically feasible, were not considered further.

The economic and environmental goals used in the analysis refer to broad policies established by the Water Resources Council for planning the use of water and related land resources. General National Economic Development (NED)/Regional Development (RD), Environmental Quality (EQ), and Social Well Being (SWB) objectives were developed on the basis of these policies for the North Branch Potomac Basin. NED and RD were treated as a single goal because NED objectives are so closely tied to the region by the Appalachian Regional Development Act of 1965. These objectives are presented in Tables 4, 5, and 6.

These objectives provided a framework for analyzing abatement measures. The NED objectives generally provide for the maximum use of the natural resources of the region. The EQ objectives relate to quantifying man's impact on the environment. Any single abatement

Table 4

PRIMARY NATIONAL ECONOMIC DEVELOPMENT/REGIONAL DEVELOPMENT OBJECTIVES
NORTH BRANCH POTOMAC RIVER BASIN

1. Increase Output of Goods and Services

   - Improve the transportation network so that goods can move more efficiently into and out of the region.

   - Promote the growth of tourist and recreational activities in the region.

2. Exploit Potential External Economies

   - Develop activities which can utilize the rich natural resource base of the region; i.e. coal mining and forestry, leading to the development of secondary industries.

3. Avoid External Diseconomies

   - Development should not be allowed to cause the deterioration of the air, land, and water resources. Environmentally sensitive areas should be restricted from development, i.e. flood plains, high slope areas, areas with restricted airsheds, etc.

4. Increase the Employment Rate

   - Attack chronic unemployment in the region by providing incentives to local employers to maintain on-the-job training programs.

5. Avoid an Unfavorable Population Distribution

   - Restrict large-scale development to clusters so that public services can be provided efficiently.

6. Promote Economic Stability

   - Promote economic stability in the region by encouraging the diversification of industrial activities.

Table 5

PRIMARY ENVIRONMENTAL QUALITY OBJECTIVES
NORTH BRANCH POTOMAC RIVER BASIN

1. Protect, manage and enhance areas of archeological, historic or aesthetic value (such as areas of unique significance as natural sites).

   - Reclaim land areas disturbed by past mining activities.

   - Improve the quality of natural waters in the area from biological and aesthetic points of view.

2. Manage the wastes and other residuals from human activity to maintain or improve the quality of air, water and land resources.

   - Eliminate or reduce industrial, domestic and associated effluents to water and air.

   - Improve the quality of natural waters in the area from a chemical standpoint.

3. Help to establish and maintain a healthy ecological equilibrium.

   - Restore a healthy aquatic ecosystem.

   - Protect and provide for wildlife.

   - Manage terrestrial natural resources such as timber and minerals.

4. Regulate the use, by man, of biological, geological and other natural resources to sustain renewable and nonrenewable resources for future generations.

   - Manage and conserve timber, minerals, wildlife and scenic areas.

   - Develop and implement sound land use controls.

Table 5 (Continued)

PRIMARY ENVIRONMENTAL QUALITY OBJECTIVES
NORTH BRANCH POTOMAC RIVER BASIN

5. **Avoid, where possible, irreversible or irretrievable commitments of natural resources.**

- **Utilize renewable resources in accomplishing other objectives.**
- **Allow for future reuse or different use of committed land.**

Table 6

PRIMARY SOCIAL WELL-BEING OBJECTIVES
NORTH BRANCH POTOMAC RIVER BASIN

1. Promote the development of an income distribution which more closely corresponds to national standards. The growth of the regional economy can improve the current situation by raising the incomes of the lower income residents of the region.

2. Promote the security of life, health, and safety in the region. Important factors determining the quality of life, health, and safety include:

   - reducing flood risk
   - ensuring an adequate water supply
   - reducing air and water pollution
   - ensuring an adequate supply of local agricultural supplies

3. Expand the educational, cultural and recreational opportunities in the region. Opportunities should be made available at costs local residents can afford.

4. Support national emergency preparedness. The regional contribution to emergency preparedness should include:

   - an adequate transportation network
   - sufficient water supply reserves
   - the provision of power supplies
   - the provision and conservation of fossil fuels

method thus attempts to satisfy the EQ objective of minimizing impact to the environment. The SWB objectives point toward general elements of society, such as health, safety, and stability, which provide a framework for the attainment of NED and EQ objectives.

The relation of acid mine drainage abatement and mined land reclamation techniques to NED objectives is more complicated. Reclamation indirectly promotes the NED objective of developing tourist and recreational activities by improving aesthetic appeal of the area. However, abatement and reclamation practices also impose significant costs, thereby restricting overall return. Thus, abatement techniques point to conflicts not only between general NED and EQ objectives, but also among specific NED objectives.

In the Task 4 Report, individual abatement and reclamation techniques were described and the important elements of each technique were evaluated. The evaluation provided an analysis of the specific relationships of each technique to NED and EQ objectives. The following techniques were evaluated and discussed in the Task 4 Report.

1) Surface Mines

- Water Infiltration and Erosion Control
- Handling Pollution-Forming Materials

- Regrading
- Revegetation

2) Underground Mines

- Daylighting
- Water Infiltration Control
- Drainage Tunnels
- Mine Sealing

3) Treatment

- Neutralization Process
- Aeration Methods

As the Task 4 Report pointed out, however, use of a single abatement technique is rarely sufficient to control pollution or upgrade an area. More often, the most effective abatement plan is a combination of many individual techniques applied on a case-by-case basis. It is, in essence, the relationship of the entire abatement plan to all objectives that must be determined in evaluation of alternatives. While the advantages and disadvantages of various abatement techniques were considered, the analysis of the impact of total plans formed the basis for selection of NED, EQ and overall best plan.

Reclamation and Abatement Costs

For purposes of preliminary planning required to satisfy the objectives of this stage of study, it was assumed that all sites were more or less typical and abatement/reclamation cost estimates were established to reflect this "typical" condition. Since "typical" is a somewhat nebulous term, a brief definition of reclamation requirements by surface mine class was developed:

Class 1 - This class consists exclusively of active strip mines, regardless of whether coal extraction or reclamation is in progress. Existing surface mining regulations within West Virginia and Maryland require complete reclamation of all active strip mined lands by the operator and are stringently enforced. Therefore, no reclamation costs were applied to Class 1 surface mines.

Class 2 - Class 2 surface mines have generally been satisfactorily reclaimed, minimizing the need for application of additional reclamation costs. A cost of $500 per acre was applied to lands in this class to permit limited spot treatment or reclamation where required. This will generally cover the costs of soil preparation (scarification, lime, fertilizer) and revegetation (seed and mulch).

Class 3 - These surface mines generally exhibit some degree of reclamation — partial regrading and revegetation or natural recovery of vegetative species on unreclaimed mine surfaces. An average reclamation cost of $900 per acre was applied to all Class 3 lands. This value includes $500 per acre for soil preparation and revegetation, and $400 per acre for minor regrading or recontouring required to improve drainage or cover toxic materials.

Class 4 - Class 4 surface mines are those requiring a moderate reclamation effort, and are expected to represent the average condition of unreclaimed surface mined lands in the study area. An average reclamation cost of $1,900 per acre was applied to cover burial of toxic materials, moderate regrading of the entire site, soil preparation and revegetation.

Class 5 - This class represents surface mined land in which an extensive reclamation effort is required. Such surface mines are generally unregraded, unvegetated, and located on steep slopes. The steep slopes, in particular, greatly increase reclamation costs for Class 5 surface mines. A cost of $3,100 per acre was applied to all Class 5 lands to cover burial of toxic spoil, regrading of the entire site to a moderately sloping configuration (terrace backfill), treatment of impounded waters, construction of sediment ponds, soil preparation, and revegetation.

Class 6 - Surface mine reclamation techniques are also applied to refuse piles, which consist of the waste materials from underground coal mines. This underground mine refuse material is generally much more toxic than surface mine spoil and as a result, reclamation is more difficult and costs are higher. A reclamation cost of $3,750 per acre was applied to all refuse piles, and will generally cover regrading, purchase and placement of cover material (topsoil, flyash, sewage sludge), sedimentation basins and revegetation.

In addition to the above-defined reclamation costs, highwall reduction was considered an independent reclamation measure. Based on mining and reclamation experience, it was assigned a cost of $10 per lineal foot of highwall, regardless of the class of surface mine in which the highwalls occur. This cost assumes an average highwall height of 50 feet, a fairly representative figure for the North Branch Potomac River Basin.

The tasks of establishing underground mine-contributed acid loads and computing abatement costs were extremely difficult due to both the large size of the study area and the limited time and general information available. In a planning study of this nature, it is virtually impossible to define underground mining in specific areas at the level necessary to determine both feasibility and accurate costs of at-source abatement. Underground mine at-source abatement cost projections require an accurate knowledge of the hydraulic head which would ultimately be encountered by any type of seal, the exact limits of mining, the locations and number of entryways and airways, locations of weakened or punctured coal outcrop barriers, and zones of surface subsidence. This site-specific information is vital to the accurate assessment of at-source abatement feasibility, requirements, and costs in underground mined areas.

Initially, the percentage of acid mine drainage of underground mine origin for a given watershed was computed by comparing the relative amounts of surface mining versus underground mining in that watershed. This was accomplished by a careful review of surface mine areas delineated from the aerial photomaps and underground mine maps acquired through the United States Bureau of Mines and other sources. Based on this assessment, and on personal

observations during the stream sampling and helicopter mined-land surveillance programs, an estimate was made of the percentage of acid mine drainage emanating from both surface and underground mines. Previous studies by many agencies in acid producing watersheds have revealed that, when the extent of underground and surface mining are approximately equal, roughly 75% of the observed acid mine drainage originates in underground mines. Therefore, in areas of equivalent underground and strip mining intensity, 75% of the acid load was attributed to underground mines. Where underground mines were more extensive than surface mines, a larger percentage of acid was attributed to underground mines. Where surface mining was more extensive, less of the observed acid was attributed to the underground mines. The assigned percentages for each watershed are documented in Appendix A, Task 4.

Underground mine acid abatement costs were computed by applying reclamation costs to each pound per day of acid attributed to the underground mines. To derive these costs, a major mine discharge within the basin was selected for cost analysis. The objective of this cost analysis was the development of a set of underground mine acid abatement costs which would be equally representative in two different circumstances: 1) at-source abatement of deep mine acid (mine sealing

or daylighting), a permanent solution requiring no subsequent operating and maintenance costs; or 2) treatment of deep mine acid, including construction of necessary facilities and their operation for the 30 year target period utilized in this study. These two conditions are not distinguishable within this planning stage because individual mine discharge characterizations were not within the scope of work of the current study.

Based on our previous experience with both of these types of underground mine acid abatement, it was felt that a 30 year treatment cost would also be fairly representative of the cost for substituting any at-source abatement measures. Therefore, underground mine pollution abatement costs were developed assuming treatment over 30 years, but are also a valid estimate of the one-time (no operating or maintenance) costs of at-source abatement. The 30 year cost estimation period here is valid because, by the end of that period, technology will have advanced significantly, possibly permitting at-source abatement of previously treated discharges, and a major reassessment of abatement potentials and alternatives will be necessary.

To derive costs for this study, the Davis Coal and Coke Co. Mine No. 42 discharge, near the headwaters of the North Branch Potomac River in the Laurel Run Watershed (No. 5) was selected.

An average flow of 3.7 cfs and acid loading of 9500 lbs/day were assumed. Based on numbers derived in EPA's 1974 "Development Document for Interim Final Effluent Limitations Guidelines and New Source Performance Standards for the Coal Mining Point Source Category," inflated by 20% to represent 1976 dollars, an average underground mine acid abatement cost of $1100 per lb/day acid abated was derived.

To make the derived abatement costs more realistic when applied in at-source abatement considerations, a series of three different cost factors were utilized to compute underground mine water pollution abatement costs. These factors were based on the anticipated degree of difficulty of abating the acid — as determined by previous experience in abating acid underground mine drainage. This consideration is insignificant where treatment is the only applicable abatement solution, but it is critical to effective cost estimation where at-source abatement is feasible. The three costs factors utilized in this computation are as follows:

1) A low abatement cost of $400 per lb/day acid was applied to the first 50% of each watershed's underground mine acid. This represents the portion of an area's acid that can generally be abated with relatively simple, inexpensive techniques.

2) A mid-range abatement cost of $1,300 per lb/day acid was applied to the next 25% of each watershed's underground mine acid load. This higher cost results from the greater complexity of the abatement techniques required to eliminate this portion of the acid mine drainage, assuming the first 50% of the watershed's acid has already been abated.

3) A high abatement cost of $2,300 per lb/day acid was applied to the last 25% of each watershed's acid. This portion of the acid is extremely difficult to abate because the required technology does not yet exist or because the existing potential abatement techniques are not financially feasible. This cost was applied to the entire remaining 25% of each watershed's acid on the assumption that existing abatement or treatment techniques will be employed where present technology appears inadequate for permanent abatement.

The cost effectiveness of an acid mine drainage reclamation or abatement project is the cost in dollars of eliminating each pound of acid emanating from the subject site, and is obtained by dividing the reclamation or abatement cost by the predicted acid load that would be abated by that work. These values were computed individually for the surface mine reclamation work, the underground mine pollution abatement work, and the overall reclamation and abatement work in each of the study area's acid producing watersheds. Iron and sulfate producing watersheds, as well as unpolluted watersheds, have no computed cost effectiveness values because the relationships between these pollutants and the costs of abating them are more variable and less clearly understood.

Acid loads, estimated abatement percentages, surface mine reclamation costs with and without highwall reduction, underground mine acid abatement costs, overall reclamation and abatement costs, and cost effectiveness values are summarized in Tables 7, 8, 9 and 10; which begin on page 150.

Quantification of Impacts

Impact assessment is an objective analysis conducted to identify and measure, where possible, the likely economic, social, and environmental effects generated by an abatement plan or alternative. These effects form the basis for evaluating the beneficial and adverse contributions of the plans. The abatement plans and their impacts are analyzed in relation to four general goals, which were established by the Water Resources Council for planning water and land resources. Those goals are:

- National Economic Development (NED)
- Environmental Quality (EQ)
- Regional Development (RD)
- Social Well Being (SWB)

The purpose of defining these goals and objectives is to ensure that major water resource projects improve the quality of life of the people. The planning process provides an evaluation procedure which generates

relevant information on project impacts in relation to these goals and objectives. Thus, risk and uncertainty associated with the project are reduced and trade-offs between specific objectives can be carefully defined.

Each alternative developed, including "do-nothing" plan, was assessed in relation to previously defined base year conditions. Since National Economic Development objectives are closely tied to the study region by the Appalachian Regional Development Act of 1965, NED and RD were treated as a single goal. The achievement of development goals was measured by the dollar value of economic benefits generated by the project.

The impacts on Environmental Quality and Social Well Being objectives were necessarily somewhat more subjective and were more difficult to place finite values on. General ranking schemes — subjective — were used to measure an abatement alternative's achievement of these goals.

The impacts expected to occur from any of the plans developed are caused by one of two general activities — land reclamation and water quality improvement. For any alternative evaluated, there are certain impacts, primarily beneficial, which can be expected to occur. Many of the land or water-oriented benefits can be quantified in terms

TABLE 7

RECLAMATION AND ABATEMENT SUMMARY

WATER-SHED NO.	DESCRIPTION	UNDERGROUND MINES*		SURFACE		
		ACID LOAD (lbs/day)	ABATEMENT COST ($ X 1000)	ACID LOAD (lbs/day)	ESTIMATED REDUCTION (%)	ESTIMATED REDUCTION Load (lbs/day)
1	Main Stem - Source to Wilsonia, West Virginia	0	$0	0	-	-
2	Main Stem - Wilson, West Virginia to Read Oak Creek	0	0	0	-	-
3	Deakin Run	84	0	0	-	-
4	Elk Run	0	0	462	90	416
5	Laurel Run	10,050	$11,055	1,117	90	1,000
6	Red Oak Creek	0	0	0	-	-
7	Sand Run	0	0	0	-	-
8	Main Stem - Red Oak Creek to Buffalo Creek	0	0	0	-	-
9	Shields Run	0	0	0	-	-
10	Buffalo Creek	3,000	0	0	-	-
11	Little Buffalo Creek	Included	with	Watershed	No.	10
12	Main Stem - Buffalo Creek to Difficult Creek	0	0	0	-	-
13	Nydegger Run	0	0	0	-	-
14	Glade Run	0	0	0	-	-
15	Difficult Creek	632	695	70	90	63
16	Main Stem - Difficult Creek to Maple Run	313	344	35	90	32
17	Stony River Above Stony River Dam	0	0	0	-	-
18	Stony River - Stony River Dam to Mt. Storm Dam	0	0	2,452	90	2,207
19	Stony River - Mt. Storm Dam to Mill Run	0	0	0	-	-
20	Stony River - Mill Run to Mouth	2,602	2,863	867	90	780
21	Trout Run	0	0	0	-	-

* ASSUME ACID ABATEMENT = 100% AND

** ACTIVE AMD TREATMENT

TABLE 7

UPPER NORTH BRANCH POTOMAC RIVER BASIN

MINES				OVERALL						
RECLAMATION COST ($ X 1000)		COST EFFECTIVENESS		ACID LOAD	ESTIMATED REDUCTION		TOTAL COST ($ X 1000)		COST EFFECTIVENESS	
Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction	(lbs/day)	(%)	Load (lbs/day)	Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction
$ 298	$ 404	–	–	0	–	–	$ 298	$ 404	–	–
16	16	–	–	0	–	–	16	16	–	–
0	0	–	–	84	0	**	0	0	–	–
229	229	550	550	462	90	416	229	229	550	550
1,024	1,203	1,024	1,203	11,167	99	11,050	12,079	12,258	1,093	1,109
67	67	–	–	0	–	–	67	67	–	–
251	323	–	–	0	–	–	257	323	–	–
5	5	–	–	0	–	–	5	5	–	–
149	175	–	–	0	–	–	148	175	–	–
91	91	–	–	3,000	–	**	91	91	–	–
–	–	–	–	–	–	–	–	–	–	–
355	565	–	–	0	–	–	355	565	–	–
132	154	–	–	0	–	–	132	154	–	–
34	34	–	–	0	–	–	34	34	–	–
209	335	3,317	5,317	702	99	695	904	1,030	1,301	1,482
95	276	2,969	8,625	348	99	345	439	620	1,272	1,797
0	0	–	–	0	–	–	0	0	–	–
1,313	1,468	595	665	2,452	90	2,207	1,313	1,468	595	665
357	555	–	–	0	–	–	357	555	–	–
242	494	310	633	3,469	97	3,382	3,105	3,357	918	993
128	236	–	–	0	–	–	128	236	–	–

COST EFFECTIVENESS = $1100 PER LB/DAY ACID ABATEMENT
PLANTS OPERATING: NO FURTHER REDUCTION

TABLE 7 (CONTINUED)

RECLAMATION AND ABATEMENT SUMMARY

WATER-SHED NO.	DESCRIPTION	UNDERGROUND MINES*		SURFACE		
		ACID LOAD (lbs/day)	ABATEMENT COST ($ X 1000)	ACID LOAD (lbs/day)	ESTIMATED REDUCTION (%)	ESTIMATED REDUCTION Load (lbs/day)
22	Maple Run	Included	with	Watershed	No.	16
23	Lostland Run	635	$ 695	70	90	63
24	Main Stem – Maple Run to Wolfden Run	214	236	24	90	22
25	Short Run	62	69	20	90	18
26	Abram Creek Above Duling Run	0	0	7,522	90	6,770
27	Abram Creek – Johnnycake Run to Emory Creek	3,762	4,139	1,254	90	1,129
28	Abram Creek – Johnnycake Run to Emory Creek	559	614	62	90	56
29	Abram Creek – Emory Creek to Mouth	1,166	1,276	130	90	117
30	Wolfden Run	0	0	0	–	–
31	Main Stem – Wolfden Run to Elklick Run	9,858	10,844	1,095	90	986
32	Three Forks Run	5,755	6,332	640	90	576
33	Deep Run	0	0	0	–	–
34	Howell Run	0	0	0	–	–
35	Elklick Run	1,220	1,342	136	90	122
36	Main Stem – Elklick Run to Savage River	12,600	13,860	1,400	90	1,260
37	Folly Run	0	0	0	–	–
38	Laurel Run	0	0	0	–	–
39	Piney Swamp Run	5,000	5,500	555	90	500
40	Main Stem – Savage River to Powderhouse Run	653	718	73	90	66
	TOTAL	58,165	60,382	17,984	–	16,193

* ASSUME ACID ABATEMENT = 100% AND

TABLE 7 (CONTINUED)

UPPER NORTH BRANCH POTOMAC RIVER BASIN

MINES				OVERALL						
RECLAMATION COST ($ X 1000)		COST EFFECTIVENESS		ACID LOAD	ESTIMATED REDUCTION		TOTAL COST ($ X 1000)		COST EFFECTIVENESS	
Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction	(lbs/day)	(%)	Load (lbs/day)	Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction
-	-	-	-	-	-	-	-	-	-	-
$ 337	$ 388	$ 5,349	$ 6,158	705	99	698	$ 1,037	$ 1,088	$1,486	$1,559
460	689	31,636	42,045	238	99	236	696	925	2,949	3,919.
87	103	4,833	5,722	82	98	80	156	172	1,950	2,150
1,680	1,771	248	262	7,522	90	6,770	1,680	1,771	248	262
232	419	208	371	5,016	98	4,891	4,374	4,558	894	932
38	81	697	1,446	621	99	615	652	695	1,060	1,130
309	431	2,641	3,684	1,295	99	1,283	1,585	1,707	1,235	1,330
181	302	-	-	0	-	-	181	302	-	-
192	370	194	375	10,953	99	10,844	11,036	11,214	1,018	1,034
310	531	536	921	6,395	99	6,331	6,640	6,862	1,049	1,084
327	599	-	-	0	-	-	327	599	-	-
35	35	-	-	0	-	-	35	35	-	-
165	293	1,352	2,402	1,356	99	1,342	1,507	1,635	1,123	1,218
448	942	356	748	14,000	99	13,860	14,308	14,802	1,032	1,068
73	139	-	-	0	-	-	73	139	-	-
94	182	-	-	0	-	-	94	139	-	-
414	820	828	1,640	5,555	99	5,914	6,320	6,320	1,075	1,149
480	756	7,272	11,455	726	99	719	1,198	1,474	1,666	2,050
10,857	15,481	-	-	76,148	-	71,678	71,856	76,024	-	-

COST EFFECTIVENESS=$1100 PER LB/DAY ACID ABATEMENT

TABLE 8

RECLAMATION AND ABATEMENT SUMMARY

WATER-SHED NO.	DESCRIPTION	UNDERGROUND MINES*		SURFACE		
		ACID LOAD (lbs/day)	ABATEMENT COST ($ X 1000)	ACID LOAD (lbs/day)	ESTIMATED REDUCTION	
					(%)	Load (lbs/day)
1	Main Stem - Above Savage River Dam	0	$0	0	-	-
2	Main Stem - Below Savage River Dam	0	0	0	-	-
3	Aaron Run	4,500	4,950	500	90	450
	TOTAL	4,500	4,950	500	-	450

* ASSUME ACID ABATEMENT = 100% AND

TABLE 8

SAVAGE RIVER BASIN

MINES				OVERALL						
RECLAMATION COST ($ X 1000)		COST EFFECTIVENESS		ACID LOAD	ESTIMATED REDUCTION		TOTAL COST ($ X 1000)		COST EFFECTIVENESS	
Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction	(lbs/day)	(%)	Load (lbs/day)	Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction
$0	$0	-	-	0	-	-	$0	$0	-	-
446	560	-	-	0	-	-	446	560	-	-
347	407	$771	$904	5,000	99	4,950	5,297	5,357	$1,070	$1,082
$793	$967	-	-	5,000	-	4,950	$4,743	$5,917	-	-

COST EFFECTIVENESS=$1100 PER LB/DAY ACID ABATEMENT

TABLE 9

RECLAMATION AND ABATEMENT SUMMARY

WATER-SHED NO.	DESCRIPTION	UNDERGROUND MINES*		SURFACE		
		ACID LOAD (lbs/day)	ABATEMENT COST ($ X 1000)	ACID LOAD (lbs/day)	ESTIMATED REDUCTION (%)	ESTIMATED REDUCTION Load (lbs/day)
1	Sand Spring Run	574	$ 632	64	90	58
2	Main Stem - Wright's Crossing to Midland, Maryland	0	0	-	-	-
3	Winebrenner Run	310	342	34	90	31
4	Woodland Creek	0	0	-	-	-
5	Neff Run	198	218	66	90	59
6	Main Stem - Midland to Moscow, Maryland	2,023	2,225	225	90	203
7	Squirrel Neck Run	0	0	-	-	-
8	Elklick Run	0	0	-	-	-
9	Hill Run	56	64	19	90	17
10	Koontz Run	0	0	-	-	-
11	Jackson Run	0	0	-	-	-
12	Laurel Run	177	194	532	90	479
13	Main Stem - Below Moscow, Maryland	15,636	17,200	3,909	90	
14	Butcher Run	0	0	125	90	113
15	Moores Run	604	664	201	90	181
16	Unnamed Tributary - Dogwood Flats, Maryland	1,337	1,470	148	90	133
17	Mill Run	4,847	5,332	255	90	230
	TOTAL	25,762	$28,341	5,578		5,022

* ASSUME ACID ABATEMENT = 100% AND

TABLE 9

GEORGES CREEK BASIN

MINES				OVERALL							
RECLAMATION COST ($ X 1000)		COST EFFECTIVENESS		ACID LOAD	ESTIMATED REDUCTION		TOTAL COST ($ X 1000)		COST EFFECTIVENESS		
Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction	(lbs./day)	(%)	Load (lbs/day)	Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction	
$ 293	$ 309	$ 5,052	$ 5,328	638	99	632	$ 925	$ 941	$ 1,611	$ 1,639	
206	228	–	–	0	–	–	206	228	–	–	
99	99	3,194	3,194	344	99	341	441	441	1,293	1,293.	
249	261	–	–	0	–	–	249	261	–	–	
308	392	5,220	6,644	264	97	257	526	610	2,047	2,374	
533	928	2,626	4,571	2,248	99	2,226	2,758	3,153	1,239	1,416	
182	223	–	–	0	–	–	182	223	–	–	
13	13	–	–	0	–	–	13	13	–	–	
216	339	12,706	19,941	75	97	73	280	403	3,836	5,521	
378	472	–	–	0	–	–	378	472	–	–	
263	399	–	–	0	–	–	263	399	–	–	
778	1,050	1,624	2,192	709	93	656	972	1,244	1,482	1,896	
1,392	1,992	396	566	19,545	98	19,154	18,592	19,192	971	1,002	
204	342	1,805	3,027	125	90	113	204	342	1,805	3,027	
417	517	2,304	3,188	805	98	785	1,081	1,241	1,377	1,581	
235	319	1,767	2,398	1,485	99	1,470	1,705	1,789	1,160	1,217	
838	991	3,643	4,309	5,102	99	5,077	6,170	6,323	1,215	1,245	
$6,604	$8,874			31,340		30,784	$34,945	$37,275			

COST EFFECTIVENESS = $1100 PER LB/DAY ACID ABATEMENT

TABLE 10

RECLAMATION AND ABATEMENT SUMMARY

WATER-SHED NO.	DESCRIPTION	UNDERGROUND MINES *		SURFACE		
		ACID LOAD (lbs/day)	ABATEMENT COST ($ X 1000)	ACID LOAD (lbs/day)	ESTIMATED REDUCTION (%)	ESTIMATED REDUCTION Load (lbs/day)
1 thru 10	See Table	0	–	0	–	–
11	Gladen Run	0	–	0	–	–
12	Rush Run	0	–	0	–	–
13 and 14	See Table	0	–	0	–	–
15	Jennings Run	740	$ 814	82	90	74
16	Unnamed Tributary to Jennings Run	2,476	2,724	275	90	248
17	Unnamed Tributary to Jennings Run	614	676	32	90	29
18	Jennings Run	0	–	0	–	–
19	North Branch – Jennings Run	0	–	0	–	–
20	Braddock Run	0	–	0	–	–
	TOTAL	3,830	$4,214	389		351

* ASSUME ACID ABATEMENT = 100% AND

TABLE 10
WILLS CREEK BASIN

MINES				OVERALL						
RECLAMATION COST ($ X 1000)		COST EFFECTIVENESS		ACID LOAD	ESTIMATED REDUCTION		TOTAL COST ($ X 1000)		COST EFFECTIVENESS	
Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction	(lbs/day)	(%)	Load (lbs/day)	Without Highwall Reduction	With Highwall Reduction	Without Highwall Reduction	With Highwall Reduction
–	–	–	–	0	–	–	–	–	–	–
$ 2.6	$ 2.6	–	–	0	–	–	–	–	–	–
27.4	27.4	–	–	0	–	–	–	–	–	–
–	–	–	–	0	–	–	–	–	–	–
455.0	589.0	$6,149	$7,054	822	99	814	$1,269	$1,336	$1,559	$1,641
282.0	456.0	1,137	1,488	2,751	99	2,726	3,006	3,093	1,103	1,135
10.4	10.4	359	359	646	99	643	686	686	1,067	1,067
14.0	14.0	–	–	0	–	–	–	–	–	–
103.0	103.0	–	–	0	–	–	–	–	–	–
333.0	352.0	–	–	0	–	–	–	–	–	–
$1,227.4	1,555.0	–	–	4,219	–	4,183	$4,961	$5,115	–	–

COST EFFECTIVENESS=$1100 PER LB/DAY ACID ABATEMENT

of dollar values, and thus become components of the NED/RD account. The procedure employed to assign dollar values to land and water improvement included a thorough evaluation of research conducted by various organizations, as well as personal interviews with numerous individuals involved in reclamation, forestry, land use economics, agriculture, and outdoor recreation.

The first step toward impact assessment was the quantification of land-oriented impacts. Surface mining and lumbering in the North Branch Potomac River Basin have had the most significant deleterious effects upon the land. These effects include removal of vegetation and the resulting loss of wildlife habitat, soil erosion, alteration of surface drainage, decreased land values, and general loss of aesthetic amenities. Reclamation of mined land will serve to significantly improve the utility of the land and will stimulate associated activities which yield benefits to the area. These benefits include hunting, recreation, timber or agricultural production, employment opportunities, and increased land value and tax revenue. Derivation of dollar values for land-oriented impacts are discussed in depth in the Task 4 Report; the final values derived are summarized below:

- Hunting - $17.60/Acre/Year
- Aesthetics/Recreation - $12.30/Acre/Year
- Timber Production - $5.00/Acre/Year

- Agriculture - \$100.00/Acre/Year
- Employment - 30% of Annual Reclamation Cost (over 30 yrs.)
- Land Values - \$50/Acre/Year

To formulate and effectively assess alternative plans using these values, it was necessary to make assumptions concerning future use of reclaimed strip mines. Three factors were considered in determining the future land uses of these areas. Slope and accessibility act as limiting factors to the development potential of a particular parcel of land. The development potential of that parcel is equivalent to the baseline projection of adjacent land uses with similar conditions.

Three types of potential land uses were considered: urban, agricultural, and forest. A reclaimed strip was determined to be urban if it satisfied three conditions: 1) it is located within an area designated as urban development in the 1990 baseline projections; 2) access is currently provided by a paved road; and 3) the area's slope is less than 10°. Agricultural designations were applied to mines where slopes were less than 20° and where adjacent unmined areas are presently being farmed or pastured. All remaining surface mined areas were designated as forest land.

Benefits derived from improving the quality of water in the basin were quantified in terms of dollar savings to industrial and municipal water uses and revenue from fishermen and recreationists.

These impacts are discussed in detail in the Task 4 Report, and are presented below:

- Fishing - $4,570/Year/Stream Mile
- Non-Fishing Stream Recreation - $450/Year/Stream Mile
- Water Treatment Costs - $5/Million Gallons Treated

Formulation of reclamation and abatement plan alternatives and assessment of resultant water quality improvements required prediction of pollution reductions and resultant water quality improvements. These evaluations were completed during Task 4, based on two key assumptions: 1) surface mine reclamation efforts will yield a 90% reduction in surface mine pollution; and 2) abatement of acid from underground mines will be 100% effective.

Overall pollution reduction loadings and percentages were developed on an individual watershed basis during Task 4 and are presented in that report's Appendices.

PLAN FORMULATION

An abatement alternative consists of a number of different abatement techniques applied to various watersheds. The purpose of alternative formulation is achievement of some or all of the previously defined NED/RD, EQ, or SWB objectives. The abatement efforts necessary to achieve maximum acid load reductions, maximum land benefits, or both from any particular watershed were defined and costed in Task 4. With the required techniques, costs, acid reductions, and cost effectiveness for abatement work in individual watersheds determined, the next step was assembly of the variables (individual watersheds) into a number of alternate plans. A "component" of a plan, therefore, consists of a particular watershed and the reclamation or abatement activities recommended which would yield the best land benefits, the best water quality improvements, or the best combined programs in that particular watershed.

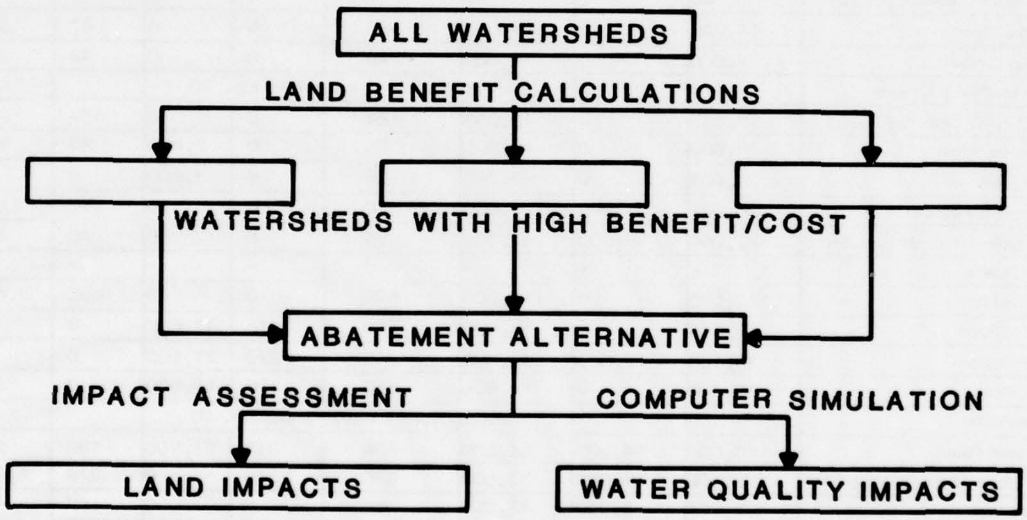
From this previously established pool of plan components — each of which consists of a particular watershed in the North Branch Potomac River Basin — a series of abatement alternatives or plans were formulated. The primary considerations in selecting components for inclusion in an alternative were the water quality effects of that component and the land use implications of reclamation of surface mines in that watershed. Plan

formulation, therefore, involved two separate but interrelated processes. The first involved assembly of watersheds which had the greatest land-oriented benefits as a result of reclamation, then assessing water quality impacts of that plan. The second involved assembly of watersheds known to be high pollution sources, then determining the land impacts of that plan.

The initial step in selecting priority watersheds was to conduct an evaluation of the land improvements associated with surface mine reclamation in each of the 80 watersheds in the North Branch Potomac River Basin. For each watershed, land use benefits were determined by assuming that all surface mines would be reclaimed and that the land would then revert to a particular use. The number of acres in each use category were assigned the economic benefits associated with that use, as derived previously. This yielded a master "working account" of costs and benefits associated with land reclamation in each individual watershed. This working account appears on page 166. Total land use benefits were divided by total reclamation costs to determine a benefit-cost ratio for reclaiming that watershed. All costs and benefits were discounted over the life of the project (30 years) and then converted to an annual equivalent cash flow at a rate of 6 3/8 percent.

The land-oriented benefit-cost ratio provided one key measure for

determining whether a particular watershed was introduced into a plan. For example, certain plans were designed to maximize land-oriented benefits. In these plans, an arbitrary minimum benefit-cost limit was established to exclude watersheds with low benefit-cost ratios. As each land improvement plan was formulated, it was incorporated into the computer simulated water quality base conditions model to determine the effect of abatement efforts on basin water quality. This process can be illustrated by Figure 22.



FORMULATING PLANS BY MAXIMIZING
LAND-ORIENTED BENEFITS

FIGURE 22

TABLE 11

MASTER ACCOUNT OF LAND RECLAMATION

NO.	WATERSHED DESCRIPTION	ANNUAL COSTS $ SURFACE	ANNUAL COSTS $ UNDER-GROUND	ANNUAL COSTS $ TOTAL	TOTAL RECLAIMED ACRES	AGRICULTURE ACRES	AGRICULTURE $ VALUE @$100	TIMBER ACRES	TIMBER $ VALUE @$5.00
	UPPER N. B. POTOMAC	1,186,000	4,645,000	5,831,000	7,781	2,934	293,400	4,817	24,085
1	Main Stem North Branch	31,000	0	31,000	145	0	0	145	725
2	Main Stem North Branch	1,000	0	1,000	32	0	0	32	160
3	Deakin Run	–	–	–	0	–	–	–	–
4	Elk Run	18,000	0	18,000	61	0	0	61	305
5	Laurel Run	92,000	847,000	939,000	367	0	0	367	1,835
6	Red Oak Creek	5,000	0	5,000	133	0	0	133	665
7	Sand Run	25,000	25,000	25,000	79	0	0	79	395
8	Main Stem North Branch	40	0	40	1	0	0	1	5
9	Shields Run	13,000	0	13,000	67	0	0	67	335
10	Buffalo Creek	7,000	0	7,000	48	0	0	48	240
11	Little Buffalo Creek	Included With Watershed No. 10							
12	Main Stem North Branch	43,000	0	43,000	184	0	0	184	920
13	Nydegger Run	12,000	0	12,000	85	56	5,600	29	145
14	Glade Run	3,000	0	3,000	56	56	5,600	0	0
15	Difficult Creek	26,000	53,000	79,000	110	0	0	110	550
16	Main Stem North Branch	21,000	26,000	47,000	90	0	0	90	450
17	Stony River	–	–	–	0	–	–	–	–
18	Stony River	113,000	0	113,000	696	0	0	696	3,480
19	Stony River	43,000	0	43,000	482	476	47,600	6	30
20	Stony River	38,000	219,000	257,000	309	279	27,900	0	0
21	Trout Run	18,000	0	18,000	156	156	15,600	0	0
22	Maple Run	Included With Watershed No. 21							
23	Lostland Run	30,000	54,000	84,000	494	312	31,200	182	910
24	Main Stem North Branch	53,000	18,000	71,000	376	0	0	376	1,880
25	Short Run	8,000	5,000	13,000	86	0	0	86	430
26	Abram Creek	136,000	0	136,000	931	916	91,600	15	75
27	Abram Creek	32,000	317,000	349,000	266	263	26,300	3	15
28	Abram Creek	6,000	47,000	53,000	61	0	0	61	305
29	Abram Creek	33,000	98,000	131,000	413	271	27,100	142	710
30	Wolfden Run	23,000	0	23,000	107	0	0	107	535
31	Main Stem North Branch	28,000	881,000	859,000	111	0	0	111	555
32	Three Forks Run	41,000	485,000	526,000	189	0	0	189	945
33	Deep Run	46,000	0	46,000	351	149	14,900	202	1,010
34	Howell Run	3,000	0	3,000	26	0	0	26	130
35	Elklick Run	22,000	103,000	125,000	167	0	0	167	835
36	Main Stem North Branch	72,000	1,063,000	1,135,000	347	0	0	347	1,735

TABLE 11
COSTS AND BENEFITS

LAND-ORIENTED BENEFITS (ANNUAL) HUNTING		AESTHETICS/ RECREATION		EMPLOYMENT (SURFACE)	EMPLOYMENT (UNDER-GROUND)	LAND VALUES		TOTAL ANNUAL BENEFITS	ANNUAL BENEFIT/COST RATIO
ACRES	$ VALUE @$17.60	ACRES	$ VALUE @$12.30	$ VALUE	$ VALUE	ACRES	$ VALUE @$50.00	$ (SURFACE/ UNDERGROUND)	(SURFACE ONLY)
7,751	136,417	5,096	62,680	354,000	1,394,000	30	1,500	872,000/2,500,000	0.74
145	2,552	145	1,784	9,000	0	0	0	14,000	0.45
32	563	32	394	400	0	0	0	1,000	1.00
-	-	-	-	-	-	-	-	-	-
61	1,074	61	750	5,000	0	0	0	7,000	0.39
367	6,459	367	4,514	28,000	254,000	0	0	41,000/295,000	0.45
133	2,341	133	1,636	2,000	0	0	0	6,000	1.20
79	1,390	79	972	7,000	0	0	0	10,000	0.40
1	18	1	12	10	0	0	0	50	1.25
67	1,179	67	824	4,000	0	0	0	6,000	0.46
48	845	48	590	2,000	0	0	0	4,000	0.57
184	3,238	184	2,263	13,000	0	0	0	19,000	0.44
85	1,496	29	357	4,000	0	0	0	11,000	0.92
56	986	0	0	1,000	0	0	0	7,000	2.33
110	1,936	110	1,353	8,000	16,000	0	0	12,000/28,000	0.46
90	1,584	90	1,107	6,000	8,000	0	0	9,000/17,000	0.43
-	-	-	-	-	-	-	-	-	-
696	12,250	696	8,561	34,000	0	0	0	58,000	0.51
482	8,483	6	74	13,000	0	0	0	69,000	1.64
279	4,910	279	3,432	11,000	66,000	30	1,500	49,000/115,000	1.29
156	2,746	0	0	5,000	0	0	0	24,000	1.33
494	8,694	182	2,239	9,000	16,000	0	0	52,000/68,000	1.73
376	6,618	376	4,625	16,000	5,000	0	0	29,000/34,000	0.55
86	1,514	86	1,058	2,000	2,000	0	0	5,000/7,000	0.63
931	16,386	15	185	41,000	0	0	0	149,000	1.10
266	4,682	3	37	10,000	95,000	0	0	41,000/136,000	1.28
61	1,074	61	750	2,000	14,000	0	0	4,000/18,000	0.67
413	7,269	142	1,747	10,000	29,000	0	0	47,000/76,000	1.42
107	1,883	107	1,316	7,000	0	0	0	11,000	0.48
111	1,954	111	1,365	9,000	249,000	0	0	12,000/261,000	0.43
189	3,326	189	2,325	12,000	146,000	0	0	19,000/165,000	0.46
351	6,178	202	2,485	14,000	0	0	0	38,000	0.83
26	458	26	320	1,000	0	0	0	2,000	0.67
167	2,939	167	2,054	7,000	31,000	0	0	13,000/44,000	0.59
347	6,107	347	4,268	22,000	319,000	0	0	34,000/353,000	0.47

TABLE 11 (CONTINUED)

MASTER ACCOUNT OF LAND RECLAMATION

WATERSHED		ANNUAL COSTS $			TOTAL RECLAIMED ACRES	AGRICULTURE		TIMBER	
NO.	DESCRIPTION	SURFACE	UNDER-GROUND	TOTAL		ACRES	$ VALUE @$100	ACRES	$ VALUE @$5.00
37	Folly Run	10,000	0	10,000	71	0	0	71	355
38	Laurel Run	14,000	0	14,000	95	0	0	95	475
39	Piney Swamp Run	63,000	422,000	485,000	271	0	0	271	1,355
40	Main Stem North Branch	58,000	55,000	113,000	318	0	0	318	1,590
GEORGES CREEK		687,000	2,173,000	2,860,000	3,932	900	90,000	2,637	13,185
1	Sand Spring Run	24,000	48,000	72,000	255	0	0	41	205
2	Main Stem	17,000	0	17,000	109	54	5,400	55	275
3	Winnebrenner Run	8,000	26,000	34,000	81	0	0	0	0
4	Woodland Run	20,000	0	20,000	217	0	0	217	1,085
5	Neff Run	30,000	17,000	47,000	118	40	4,000	78	390
6	Main Stem	78,000	171,000	249,000	397	0	0	397	1,985
7	Squirrel Neck Run	17,000	0	17,000	122	60	6,000	62	310
8	Elklick Run	1,000	0	1,000	14	0	0	14	70
9	Hill Run	26,000	5,000	31,000	115	0	0	115	575
10	Koontz Run	36,000	0	36,000	175	0	0	175	875
11	Jackson Run	31,000	0	31,000	103	0	0	103	515
12	Laurel Run	81,000	15,000	96,000	434	160	16,000	274	1,370
13	Main Stem	153,000	1,319,000	1,472,000	718	111	11,100	607	3,035
14	Butcher Run	26,000	0	26,000	112	52	5,200	60	300
15	Moores Run	40,000	51,000	91,000	185	0	0	185	925
16	Unnamed Tributary	24,000	113,000	137,000	131	0	0	131	655
17	Mill Run	76,000	409,000	485,000	646	523	52,300	123	615
WILLS CREEK		119,000	287,000	406,000	711	325	32,500	391	1,955
1	Main Stem	-	-	-	0	-	-	-	-
2	Laurel Run	-	-	-	0	-	-	-	-
3	Main Stem	-	-	-	0	-	-	-	-
4	Brush Creek	-	-	-	0	-	-	-	-
5	Main Stem	-	-	-	0	-	-	-	-
6	Schaffer's Run	-	-	-	0	-	-	-	-
7	Little Wills Creek	-	-	-	0	-	-	-	-
8	Little Wills Creek	-	-	-	0	-	-	-	-
9	Main Stem	-	-	-	0	-	-	-	-
10	Thompson Run	-	-	-	0	-	-	-	-
11	Gladden Run	200	0	200	1	0	0	1	5
12	Rush Run	2,000	0	2,000	30	30	3,000	0	0
13	Gladden Run	-	-	-	0	-	-	-	-
14	Main Stem	-	-	-	0	-	-	-	-

TABLE 11 (CONTINUED)

COSTS AND BENEFITS

LAND-ORIENTED BENEFITS (ANNUAL)								TOTAL ANNUAL BENEFITS	ANNUAL BENEFIT/COST RATIO
HUNTING		AESTHETICS/ RECREATION		EMPLOYMENT (SURFACE)	EMPLOYMENT (UNDER-GROUND)	LAND VALUES			
ACRES	$ VALUE @$17.60	ACRES	$ VALUE @$12.30	$ VALUE	$ VALUE	ACRES	$ VALUE @$50.00	$ (SURFACE / UNDERGROUND)	(SURFACE ONLY)
71	1,250	71	873	3,000	0	0	0	6,000	0.60
95	1,672	95	1,169	4,000	0	0	0	8,000	0.57
271	4,770	271	3,333	19,000	127,000	0	0	28,000/155,000	0.44
318	5,597	318	3,911	17,000	17,000	0	0	28,000/45,000	0.48
3,514	61,846	2,637	32,435	206,000	275,000	295	14,750	420,000/695,000	0.61
41	721	41	509	7,000	15,000	214	10,700	21,000/36,000	0.88
109	1,918	55	676	5,000	0	0	0	14,000	0.82
0	0	0	0	2,000	8,000	81	4,050	6,000/14,000	0.75
217	3,820	217	2,670	6,000	0	0	0	14,000	0.70
118	2,080	78	959	9,000	5,000	0	0	16,000/21,000	0.53
397	3,256	397	4,883	23,000	51,000	0	0	33,000/84,000	0.42
122	2,147	62	763	5,000	0	0	0	14,000	0.82
14	246	14	172	300	0	0	0	1,000	1.00
115	2,024	115	1,414	8,000	1,000	0	0	12,000/13,000	0.46
175	3,080	175	2,152	11,000	0	0	0	17,000	0.47
103	1,813	103	1,267	9,000	0	0	0	13,000	0.42
434	7,638	274	3,370	24,000	4,000	0	0	53,000/57,000	0.65
718	12,637	607	7,466	46,000	189,000	0	0	80,000/269,000	0.52
112	1,971	60	738	8,000	0	0	0	16,000	0.62
185	3,256	185	2,276	12,000	15,000	0	0	18,000/33,000	0.45
131	2,306	131	1,611	7,000	34,000	0	0	12,000/46,000	0.50
523	9,205	123	1,513	23,000	123,000	0	0	86,000/209,000	1.13
711	12,514	313	3,850	36,000	86,000	0	0	85,000/171,000	0.71
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
1	18	1	12	100	0	0	0	100	0.50
30	528	0	0	600	0	0	0	4,000	2.00
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-

TABLE 11 (CONTINUED)

MASTER ACCOUNT OF LAND RECLAMATION

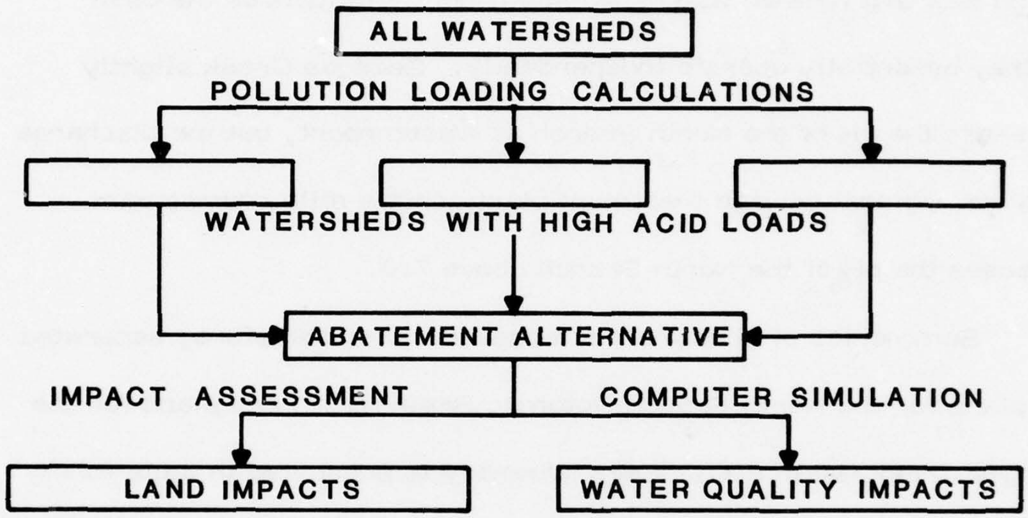
WATERSHED		ANNUAL COSTS			TOTAL RECLAIMED ACRES	AGRICULTURE		TIMBER	
		SURFACE	UNDER-GROUND	TOTAL		ACRES	$ VALUE @$100	ACRES	$ VALUE @$5.00
NO.	DESCRIPTION	$							
15	Jennings Run	45,000	88,000	133,000	224	69	6,900	155	775
16	Unnamed Tributary	35,000	170,000	205,000	171	80	8,000	91	455
17	Unnamed Tributary	1,000	29,000	30,000	5	0	0	5	25
18	Jennings Run	1,000	0	1,000	15	14	140	1	5
19	North Branch Jennings Run	8,000	0	8,000	67	67	6,700	0	0
20	Braddock Run	27,000	0	27,000	203	65	6,500	138	690
SAVAGE RIVER		74,000	380,000	454,000	657	0	657,000	657	3,285
1	Savage River above Dam	-	-	-	0	-	-	-	-
2	Savage River below Dam	43,000	0	43,000	306	306	30,600	0	0
3	Aaron Run	31,000	380,000	411,000	351	351	35,100	0	0

TABLE 11 (CONTINUED)
COSTS AND BENEFITS

LAND-ORIENTED BENEFITS (ANNUAL)								TOTAL ANNUAL BENEFITS	ANNUAL BENEFIT/COST RATIO
HUNTING		AESTHETICS/ RECREATION		EMPLOYMENT (SURFACE)	EMPLOYMENT (UNDER-GROUND)	LAND VALUES			
ACRES	$ VALUE @$17.60	ACRES	$ VALUE @$12.30	$ VALUE	$ VALUE	ACRES	$ VALUE @$50.00	$ (SURFACE/ UNDERGROUND)	(SURFACE ONLY)
224	3,942	155	1,907	14,000	27,000	0	0	27,000/54,000	0.60
171	3,010	91	1,119	10,000	51,000	0	0	23,000/74,000	0.66
0	0	0	0	200	9,000	0	0	300/9,000	0.33
15	264	1	12	300	0	0	0	1,000	1.00
67	1,179	0	0	2,000	0	0	0	10,000	1.25
203	3,573	65	800	8,000	0	0	0	20,000	0.74
657	11,564	657	8,081	22,000	114,000	0	0	111,000/225,000	1.50
–	–	–	–	–	–	–	–	–	–
306	5,386	0	0	13,000	0	0	0	49,000	1.14
351	6,178	0	0	9,000	114,000	0	0	51,000/165,000	1.65

The second method of plan formulation involved selection of watersheds which were known to be responsible for high pollution loads for inclusion in an abatement alternative. Pollution loadings formed the primary criteria for selection of priority watersheds. A "minimum" acceptable water quality of pH = 6.0 in Bloomington Lake (currently under construction) was established, and the assembly of various abatement alternatives was directed toward the achievement of this objective at the lowest possible cost. Thus, with the exception of the "do-everything" alternative, there are no "grandiose" plans involving an excessive number of watersheds. When the alternative was assembled, its water quality improvement impacts were simulated. Land benefits for the entire plan were derived in a manner similar to the initial assessment by totaling benefits for individual watersheds. This process can be illustrated on the following page.

Thus, by formulating alternatives in a manner which addresses both land use and water quality objectives, a wide range of plans which are responsive to one or both objectives were derived.



FORMULATING PLANS BY MAXIMIZING WATER QUALITY BENEFITS

FIGURE 23

ABATEMENT ALTERNATIVES

For the purpose of formulating abatement alternatives, the Georges Creek Basin and the North Branch Potomac Watershed above Westernport were considered individually. The rationale for this approach was that neither watershed significantly influences the other and they essentially operate independently. Georges Creek slightly depresses the pH of the North Branch at Westernport, but the discharge from the regional sewage treatment plant about a mile downstream increases the pH of the North Branch above 7.0.

Summaries of abatement alternatives are, therefore, separated into plans for the North Branch Potomac Basin (NBP) and plans for the Georges Creek Basin (GC). Each summary is presented in table form, and is accompanied by a map of the basin indicating the plan components or watersheds which are included in the particular plan, and the type of recommended activity — surface mine reclamation only versus surface mine reclamation and underground mine acid abatement. Additionally, a graph depicting baseline pH along the North Branch and computer simulated pH as a result of the abatement plan is provided. The graph is scaled horizontally by river miles and by river nodes. Following each abatement alternative is a system of accounts which summarizes the NED/RD, EQ, and SWB impacts of each plan.

The abatement alternatives included in the following pages are the same ten North Branch Potomac River and six Georges Creek plans assessed in the Task 4 Report. It should be pointed out before presenting these alternatives that they do not represent the only alternatives considered for the basin. At least eleven other alternatives were simulated, and are discussed in the back-up report prepared by Water Resource Engineers, Inc. Since none of these new alternatives showed any extremely significant impact improvements, they are not presented in this report.

The primary abatement alternatives, which are exclusively in a table and figure format, follow.

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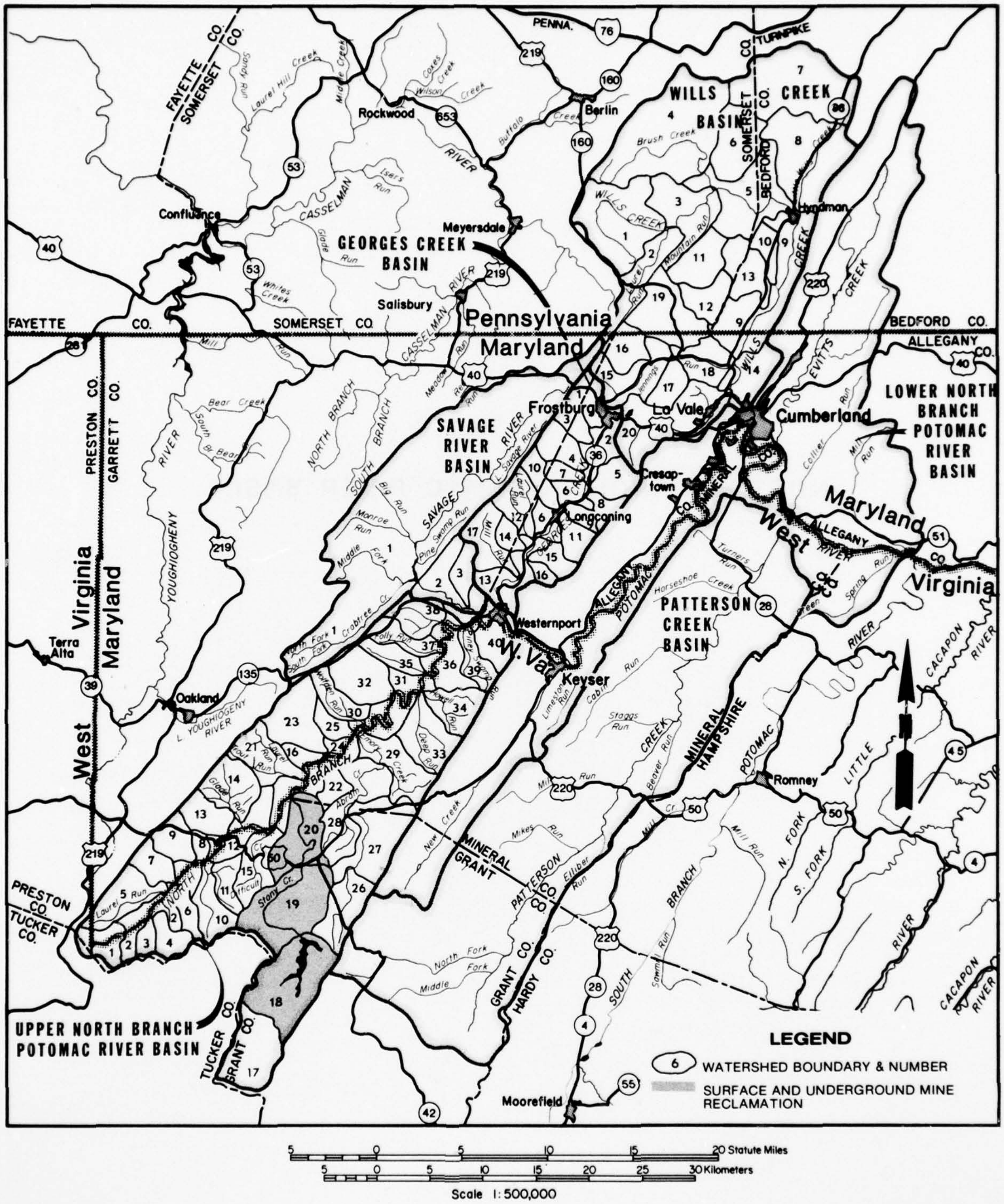
NORTH BRANCH POTOMAC RIVER BASIN



NORTH BRANCH POTOMAC RIVER BASIN
ABATEMENT ALTERNATIVE NBP-1

FIGURE 24

Table 12
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-1

Water Quality - No significant improvement in pH will occur as a result of this plan.

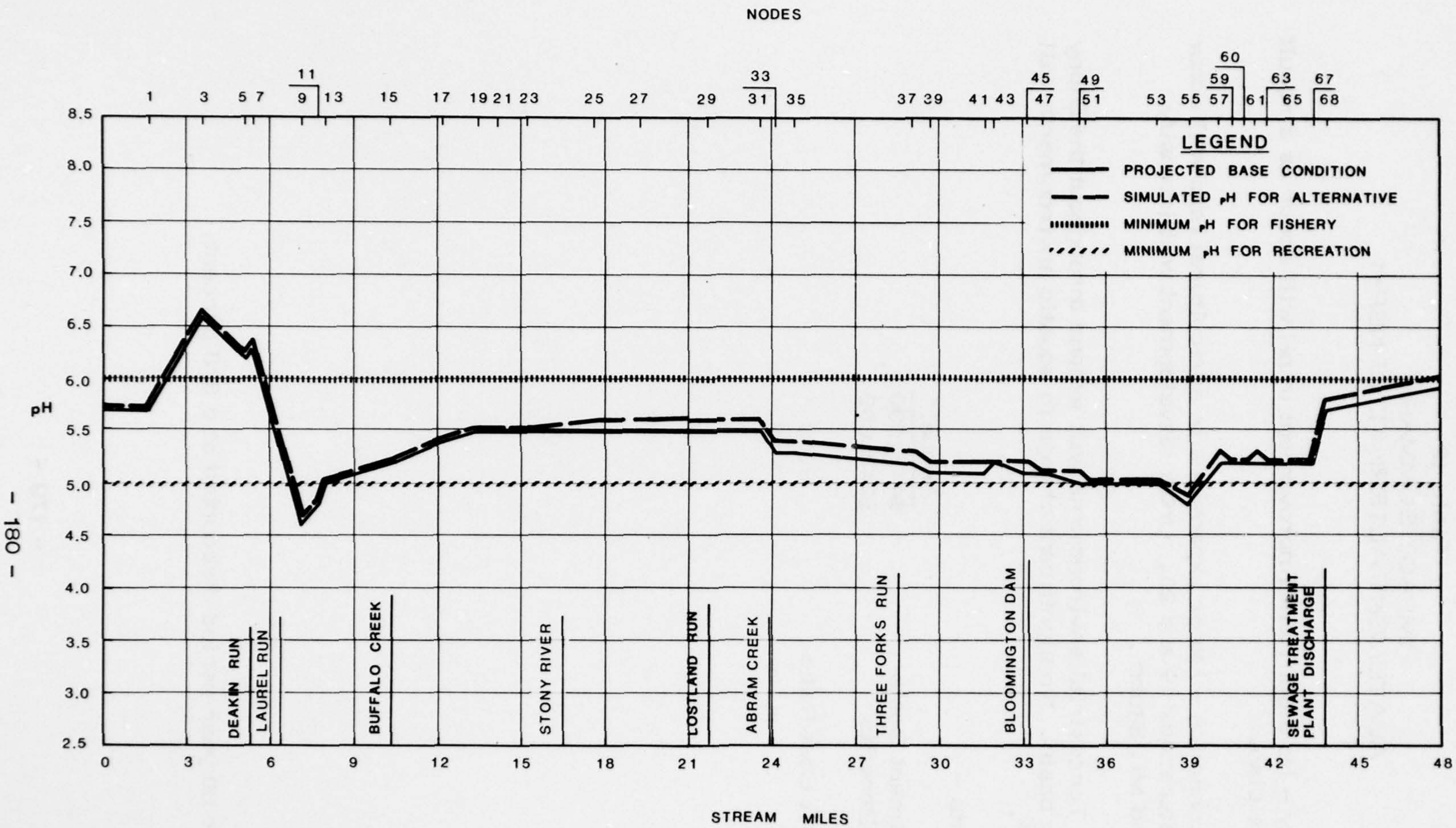
Land Use/Economics - Major expansions in agricultural land will occur in Watersheds 19 and 20. Urban development will intensify around Mt. Storm.

Ecological - Terrestrial environments will expand throughout the Stony River basin. No significant change in aquatic environments will occur.

Benefits/Costs -

	Annual*
Abatement Costs	$412,000
Plan Benefits	$242,000
Benefit Cost Ratio	0.59

*Over 30 year period discounted at 6 3/8 percent.

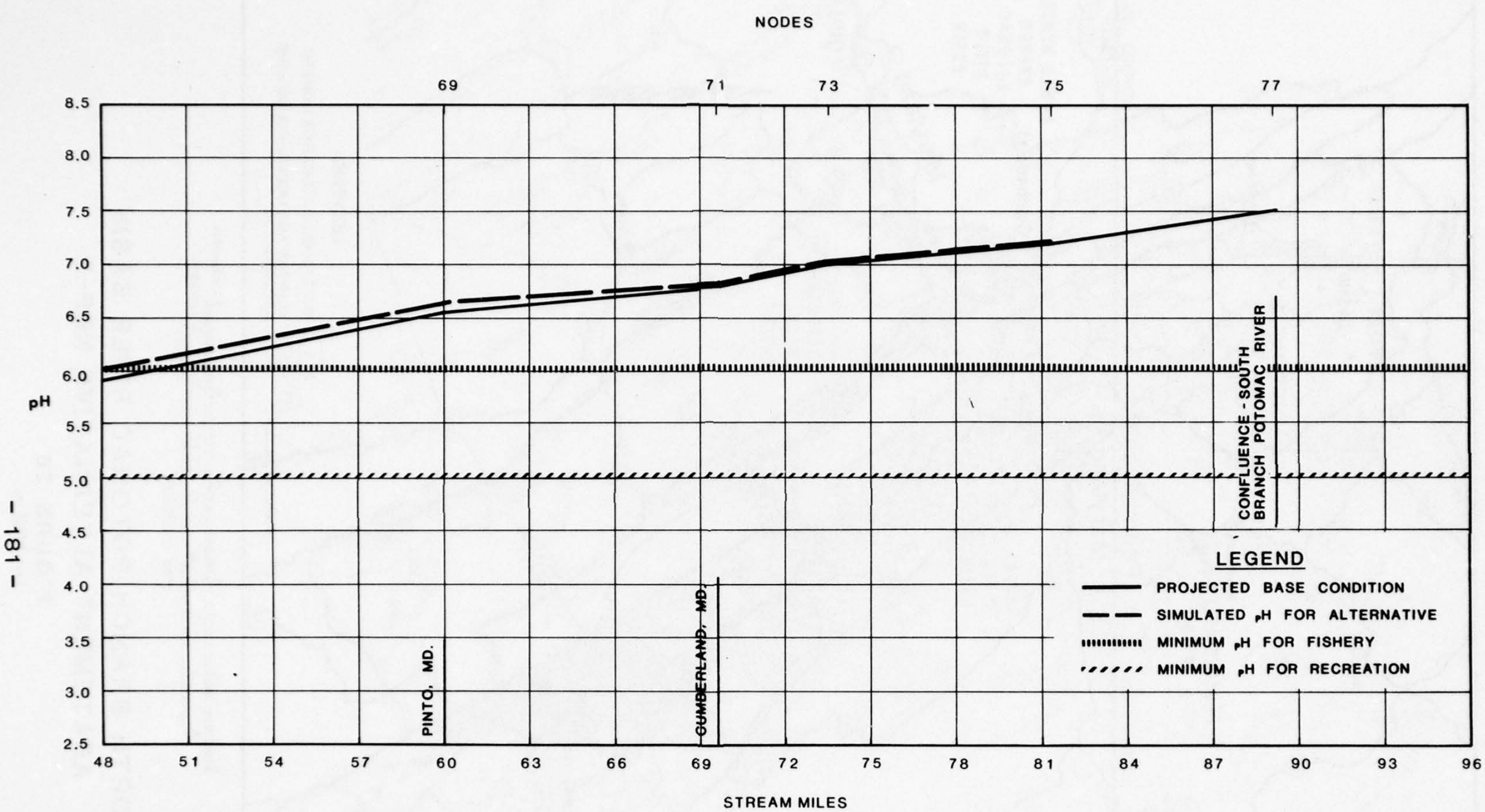


NORTH BRANCH POTOMAC RIVER BASIN

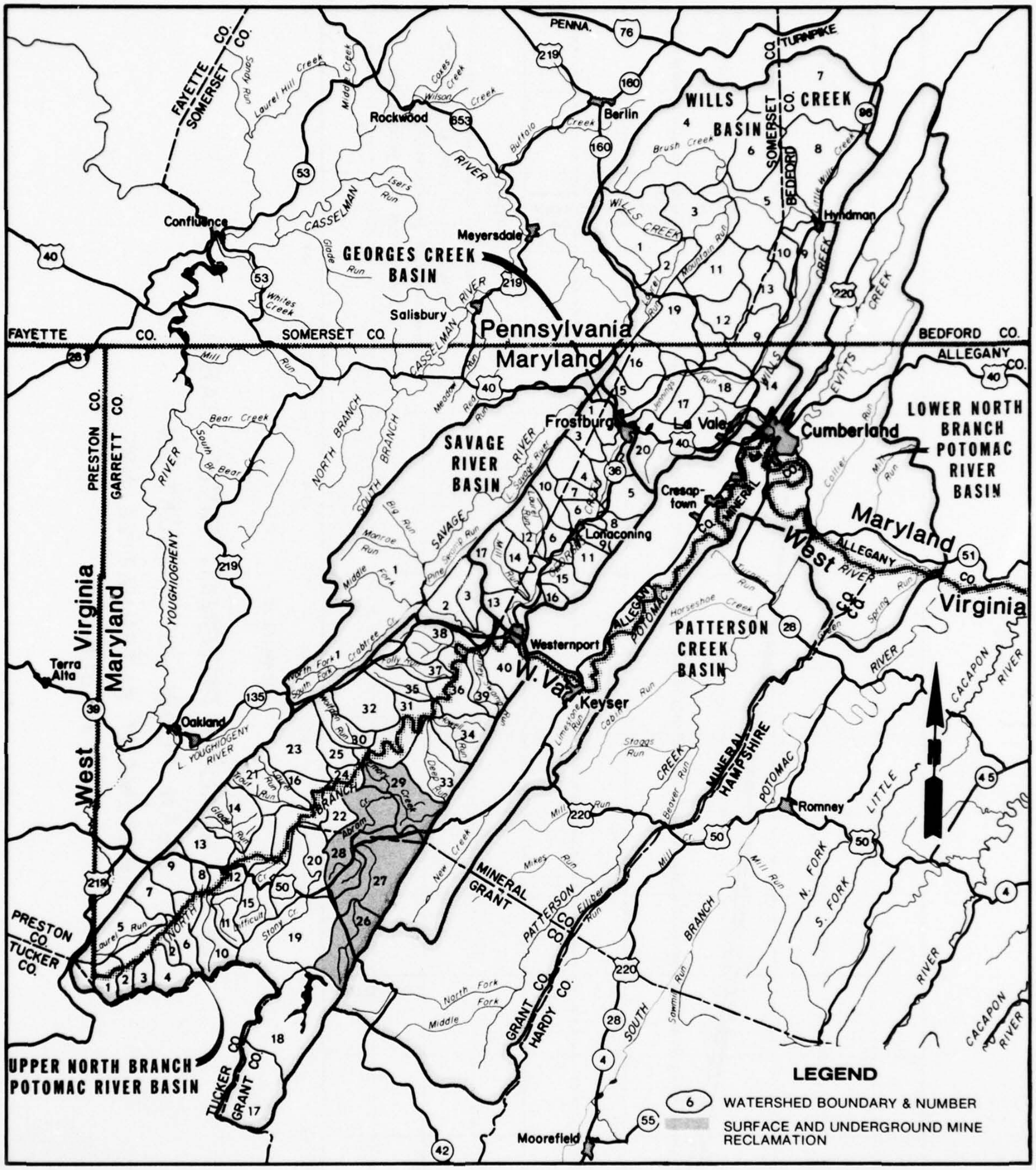
MEAN FLOW $_pH$ SIMULATION

ABATEMENT ALTERNATIVE NBP-1

FIGURE 25



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE NBP-1
FIGURE 25



5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

Scale 1:500,000

NORTH BRANCH POTOMAC RIVER BASIN

ABATEMENT ALTERNATIVE NBP-2

FIGURE 26

Table 13
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-2

Water Quality - Over 14 miles of Abram Creek will be improved to a quality supporting fishing and general recreation activities.

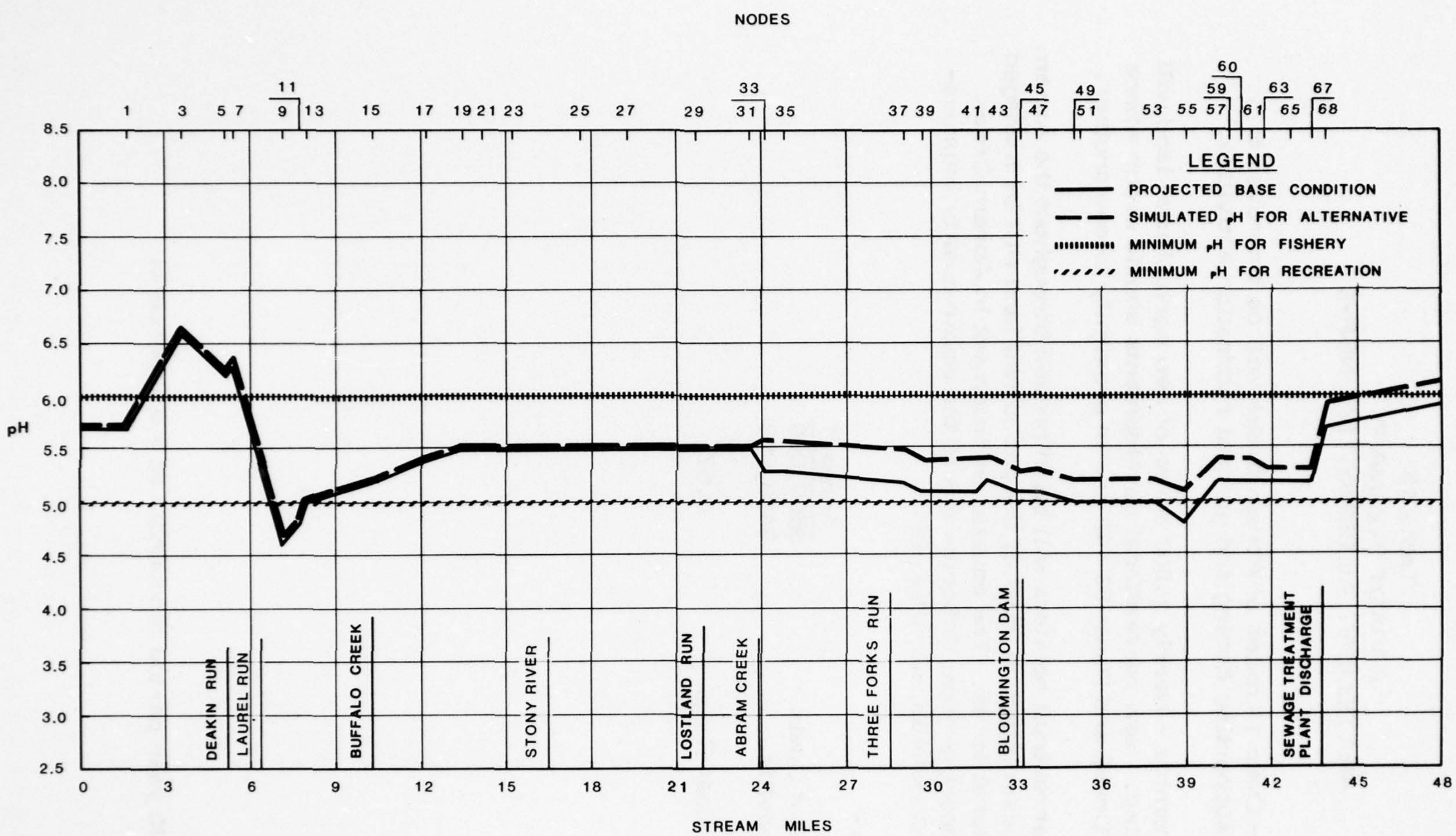
Land Use/Economics - Nearly 1,500 acres of new agricultural land will be created. New recreational developments should occur where Abram Creek and Route 50-42 are in proximity to one another.

Ecological - Terrestrial habitats will be improved throughout the Abram Creek basin although most of the reclaimed land will be managed agricultural lands. The aquatic environment in Abram Creek will support general fisheries due to the water quality improvements associated with this plan.

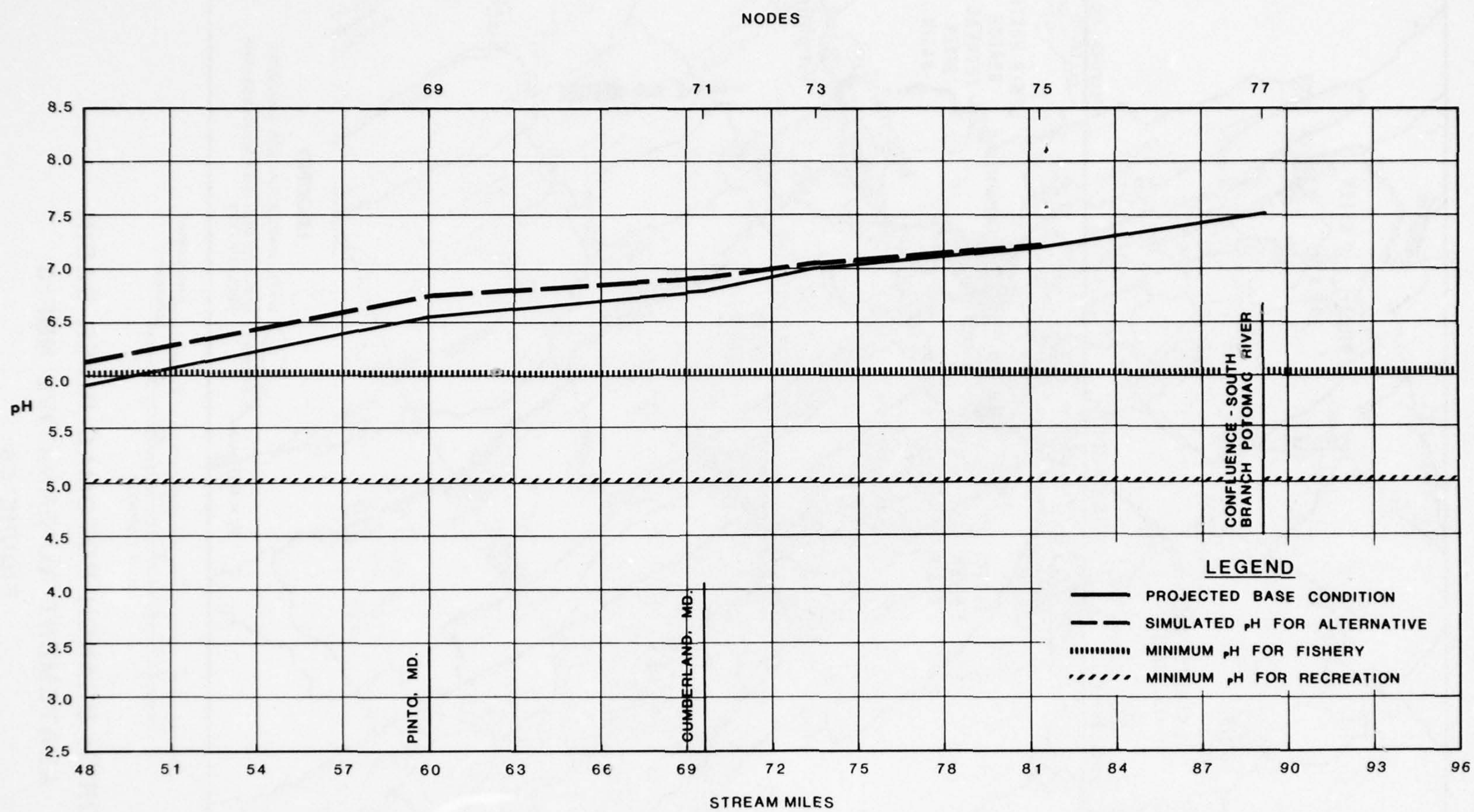
Benefits/Costs -

	Annual*
Abatement Costs	$669,000
Plan Benefits	$449,000
Benefit Cost Ratio	0.67

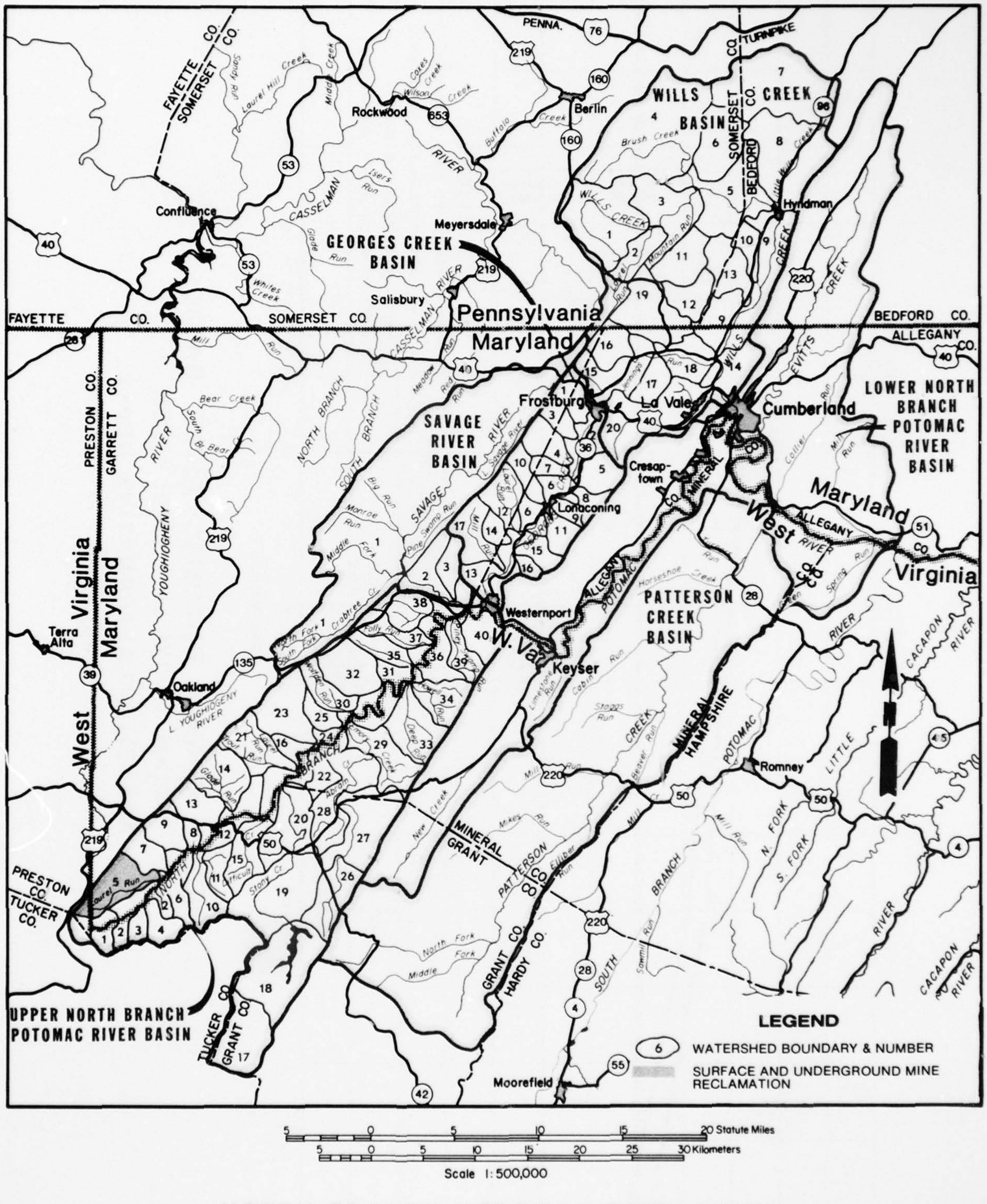
*Over 30 year period discounted at 6 3/8 percent.



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE NBP - 2
FIGURE 27



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW $_{p}$H SIMULATION
ABATEMENT ALTERNATIVE NBP-2
FIGURE 27



Scale 1:500,000

NORTH BRANCH POTOMAC RIVER BASIN
ABATEMENT ALTERNATIVE NBP-3
FIGURE 28

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NORTH BRANCH POTOMAC RIVER BASIN MINE DRAINAGE STUDY. PHASE I. --ETC(U)
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Table 14
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-3

Water Quality - Water quality improves along an 11 mile stretch of the North Branch, with pH values surpassing 6.0.

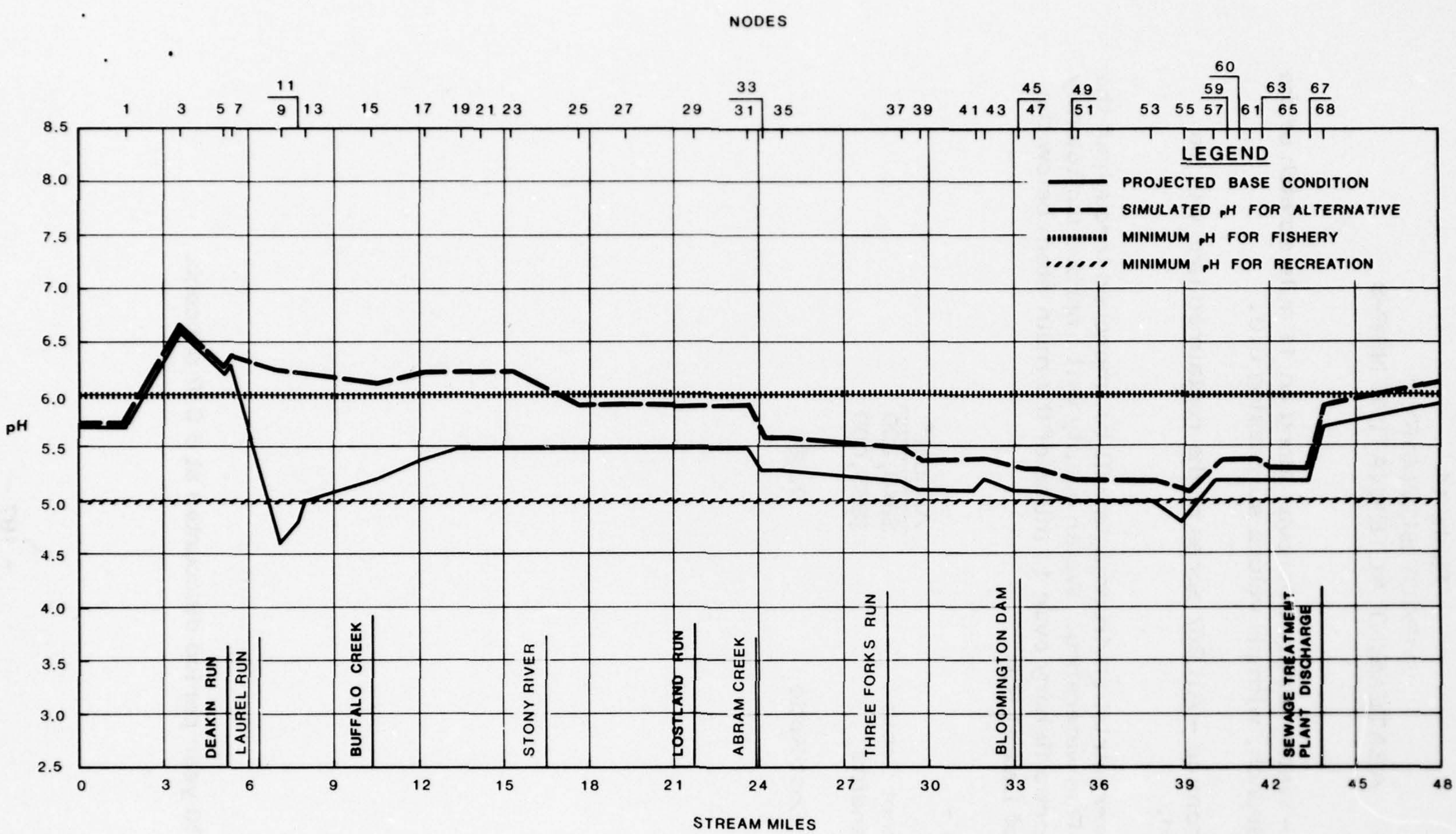
Land Use/Economics - All 367 acres of the reclaimed land will be forested.

Ecological - Terrestrial environments will be improved throughout the Laurel Run watershed. Water quality will improve sufficiently to support a fishery over 11 miles of the main stem below the mouth of Laurel Run.

Benefits/Costs -

	Annual*
Abatement Costs	$940,000
Plan Benefits	$355,000
Benefit Cost Ratio	0.38

*Over 30 year period discounted at 6 3/8 percent.

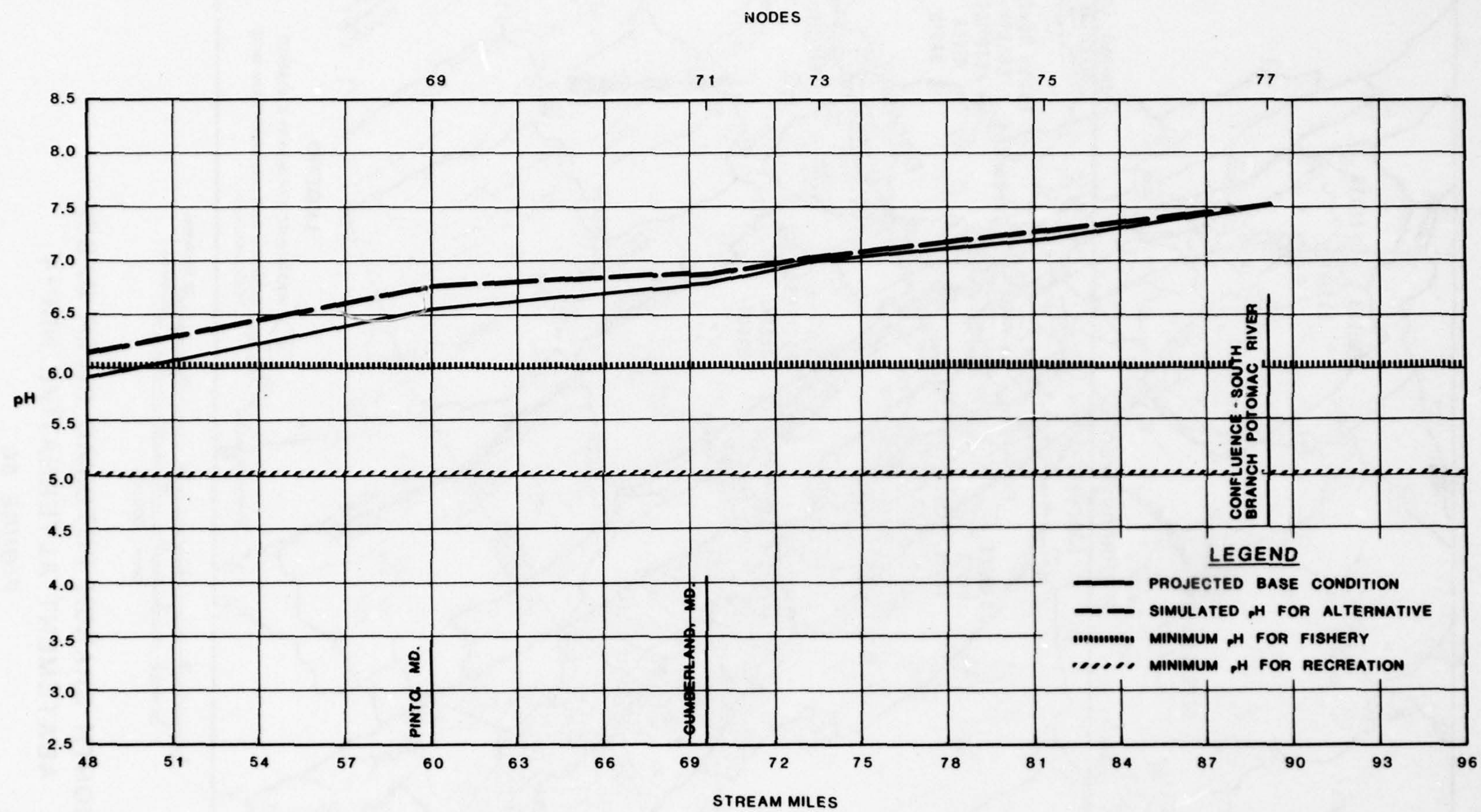


NORTH BRANCH POTOMAC RIVER BASIN

MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP - 3

FIGURE 29

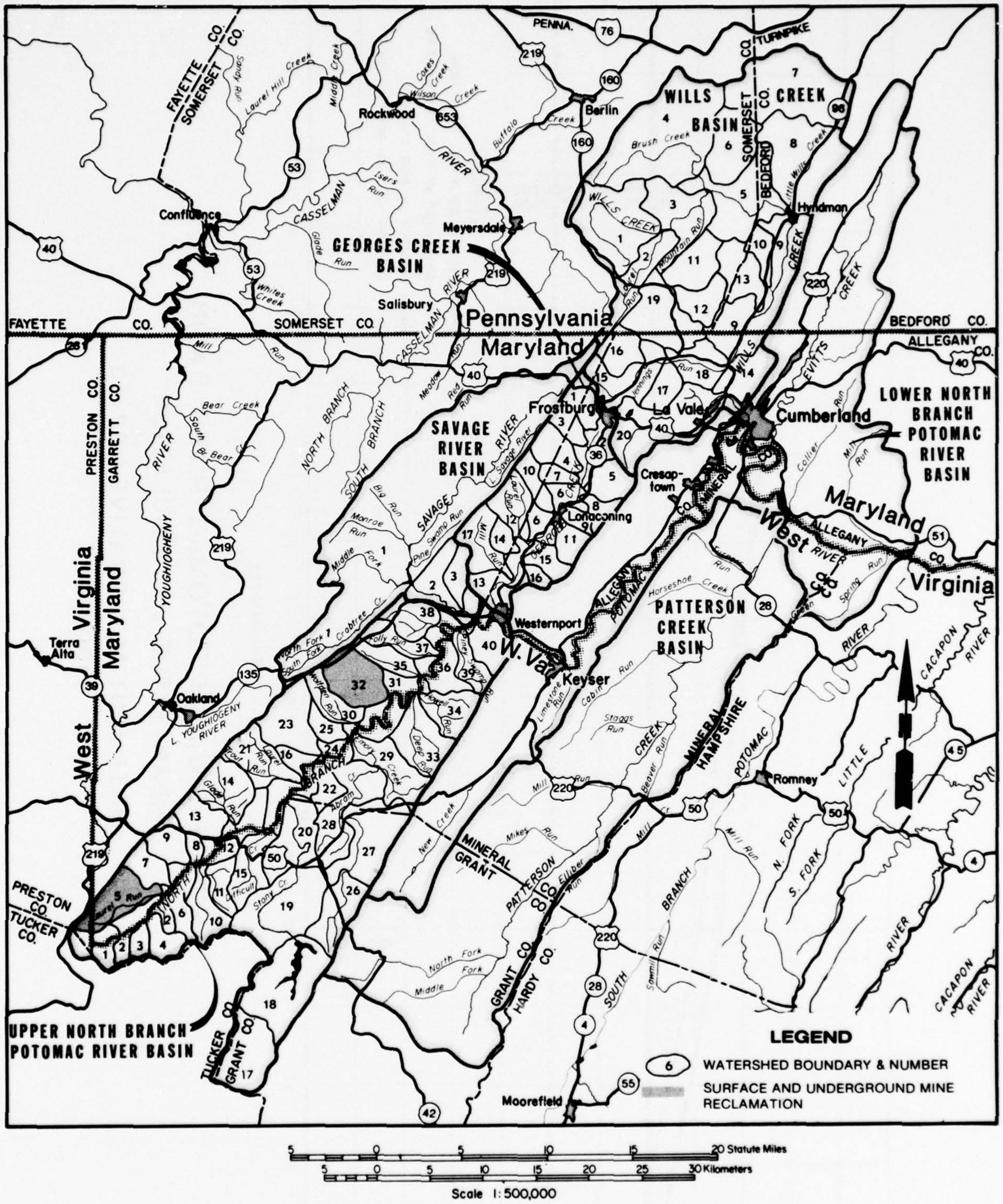


NORTH BRANCH POTOMAC RIVER BASIN

MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP - 3

FIGURE 29



NORTH BRANCH POTOMAC RIVER BASIN
ABATEMENT ALTERNATIVE NBP-4
FIGURE 30

Table 15
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-4

Water Quality - Water quality will improve over 11 miles of the main stem below the mouth of Laurel Run.

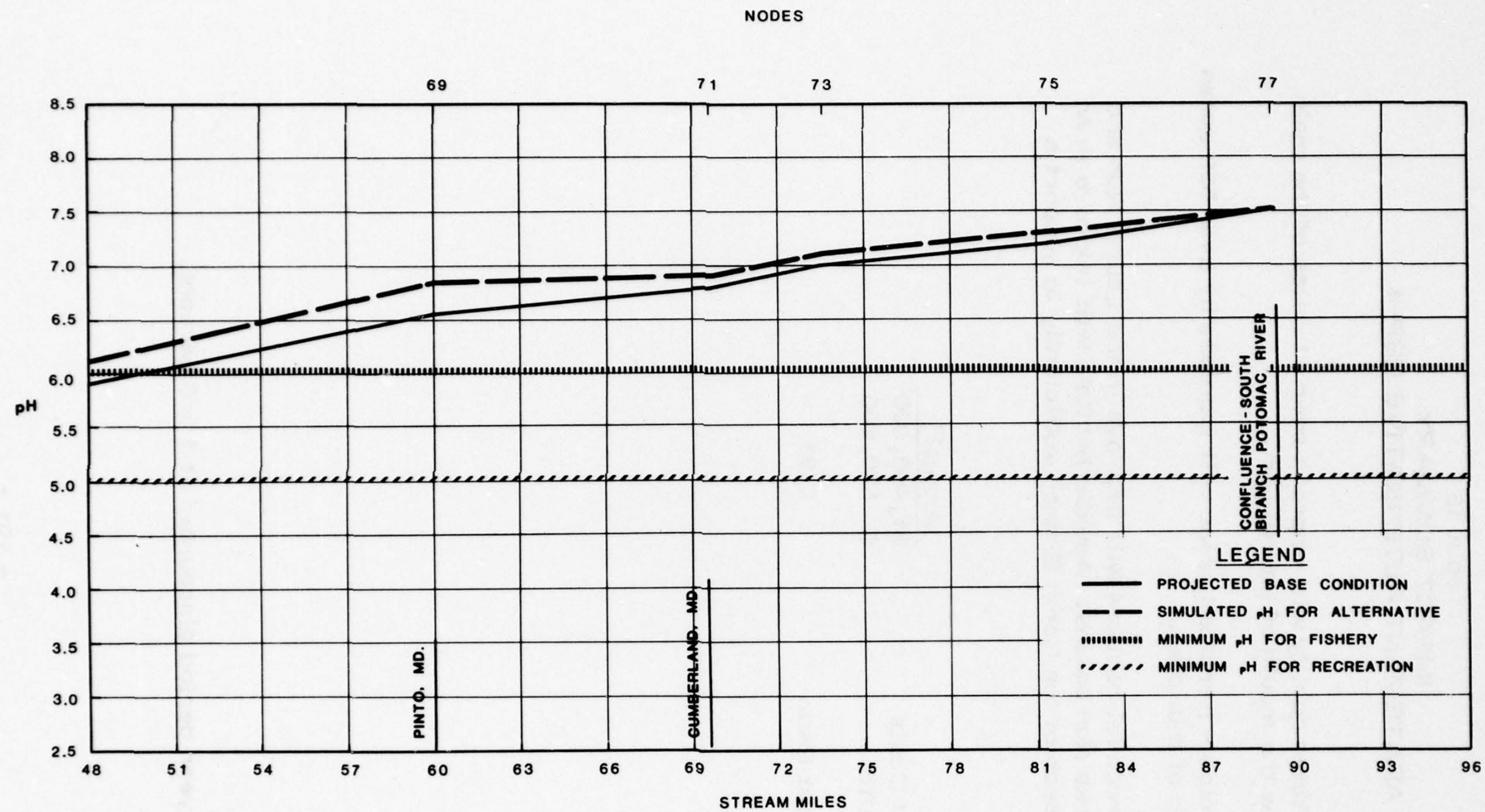
Land Use/Economics - Forested areas will increase by over 550 acres as a result of this plan.

Ecological - Terrestrial habitats will improve in the Laurel Run and Three Forks Run basins. Aquatic habitats will improve in an 11 mile reach of the North Branch sufficiently to support a fishery.

Benefits/Costs -

	Annual*
Abatement Costs	$1,466,000
Plan Benefits	$ 520,000
Benefit Cost Ratio	0.36

*Over 30 year period discounted at 6 3/8 percent.

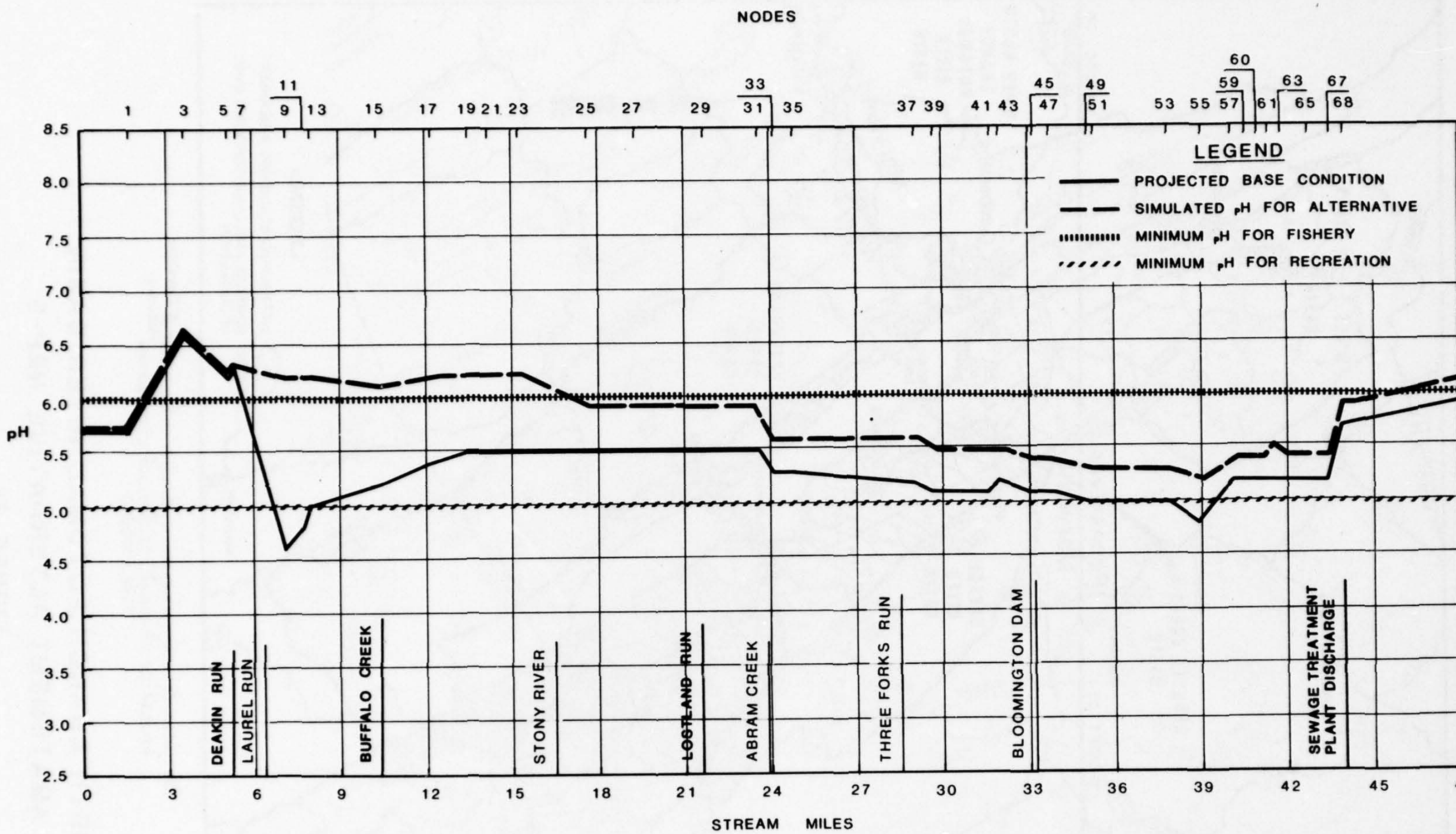


NORTH BRANCH POTOMAC RIVER BASIN

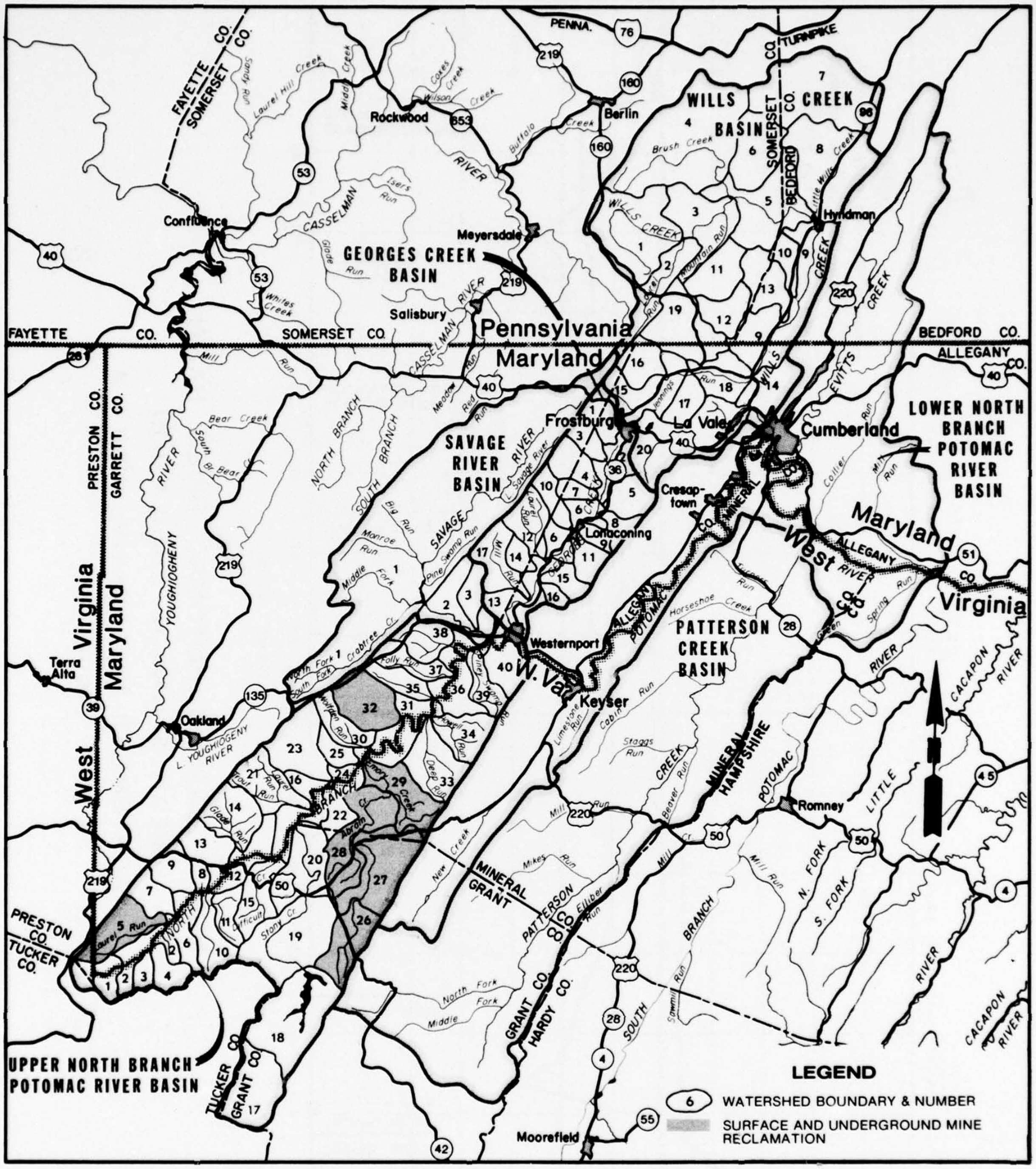
MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP-4

FIGURE 31



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE NBP - 4
FIGURE 31



5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

Scale 1:500,000

NORTH BRANCH POTOMAC RIVER BASIN
ABATEMENT ALTERNATIVE NBP-5
FIGURE 32

Table 16
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-5

Water Quality - No incremental benefit to the main stem North Branch over Alternative NBP-3; fishery could be established from Stony River upstream 11 miles. Abram Creek improved to support fishing and water recreation throughout entire basin.

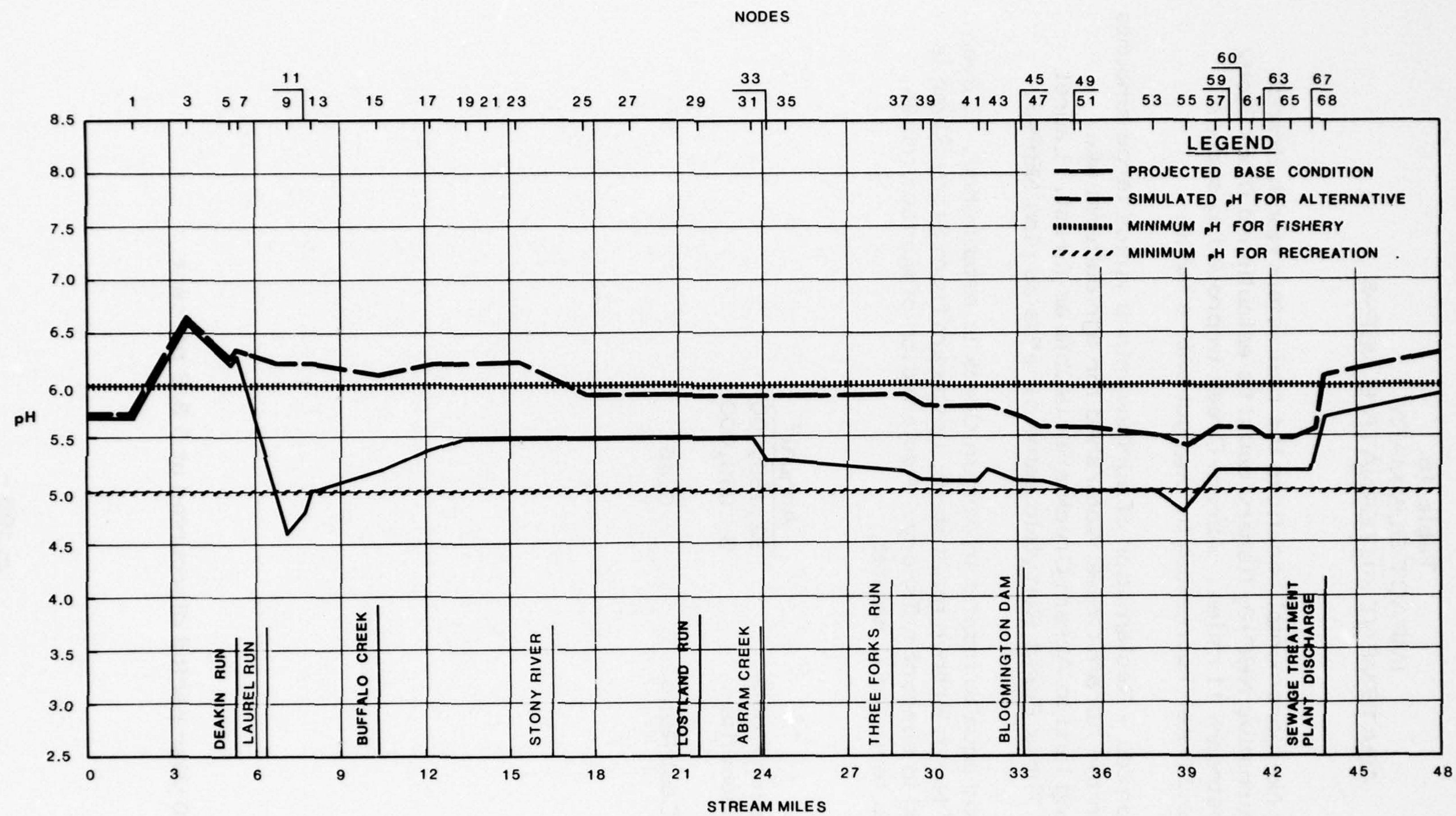
Land Use/Economics - Reclamation of surface mines yields large amounts of land in the Abram Creek Watershed for agricultural use. Remaining land in Abram Creek area usable as forest. Laurel Run and Three Forks Run yield same benefits as plan NBP-3.

Ecological - Good aquatic habitat in Abram Creek is established. Eleven miles of North Branch main stem, upstream from Stony River is improved to support a fishery. Reclamation of surface mines improves terrestrial habitat.

Benefits/Costs -

	Annual*
Reclamation Costs	$2,135,000
Project Benefits	$ 969,000
Benefit Cost Ratio	0.45

*Over 30 year period discounted at 6 3/8 percent.

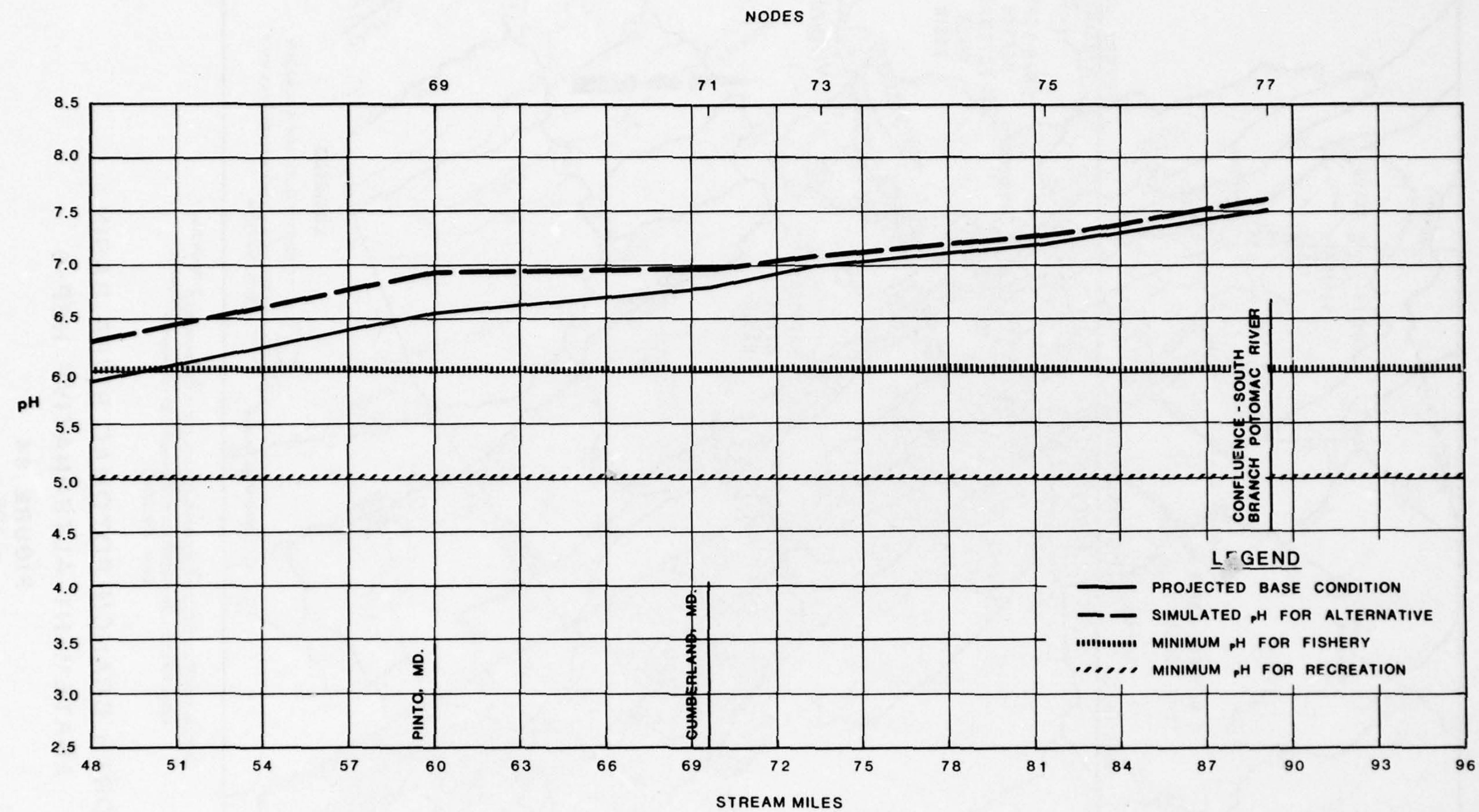


NORTH BRANCH POTOMAC RIVER BASIN

MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP - 5

FIGURE 33

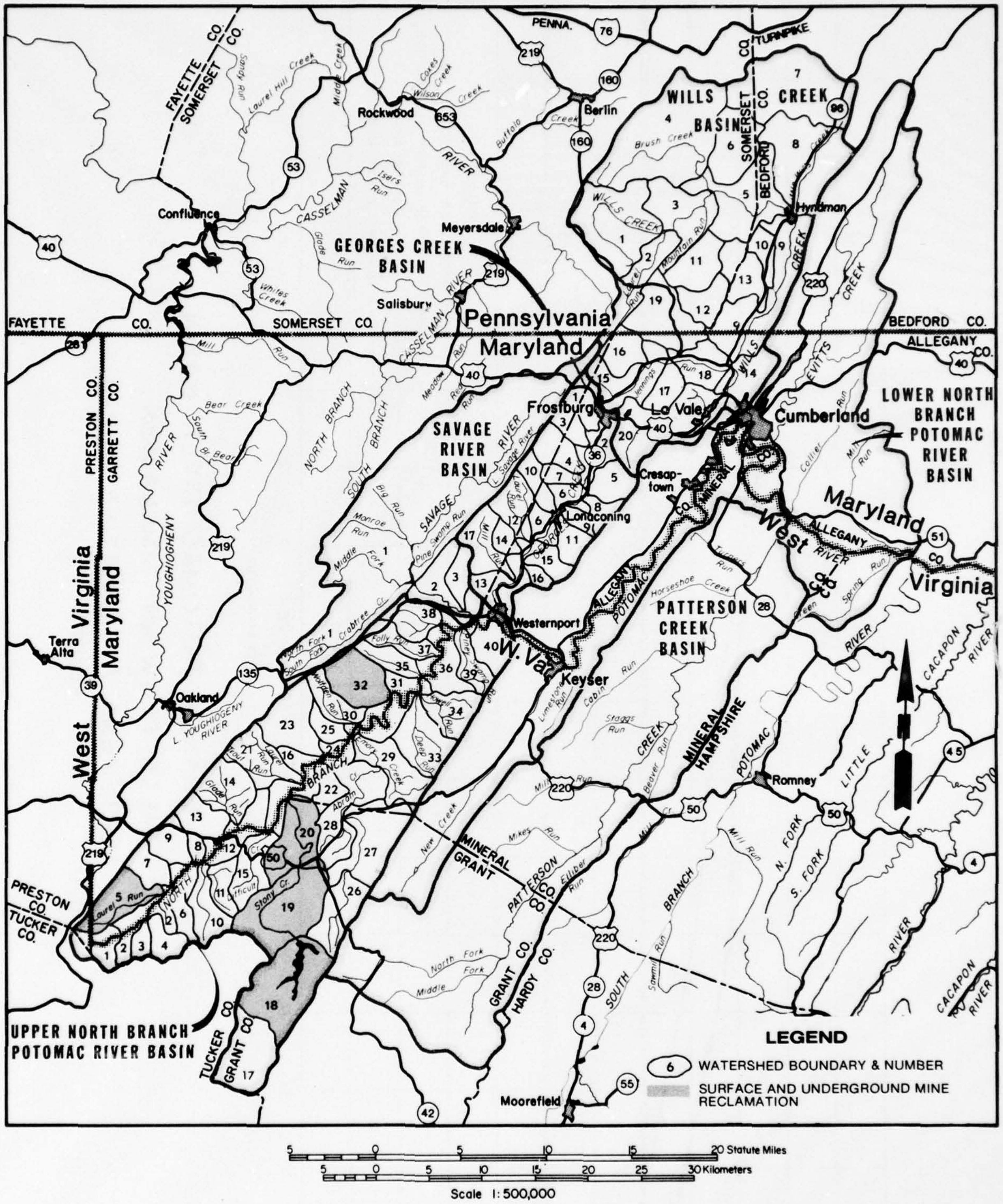


NORTH BRANCH POTOMAC RIVER BASIN

MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP-5

FIGURE 33



NORTH BRANCH POTOMAC RIVER BASIN
ABATEMENT ALTERNATIVE NBP-6

FIGURE 34

Table 17
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-6

Water Quality - Eighteen miles of main stem North Branch Potomac from Abram Creek upstream improved to support a fishery. Stony River cannot be improved to support a fishery.

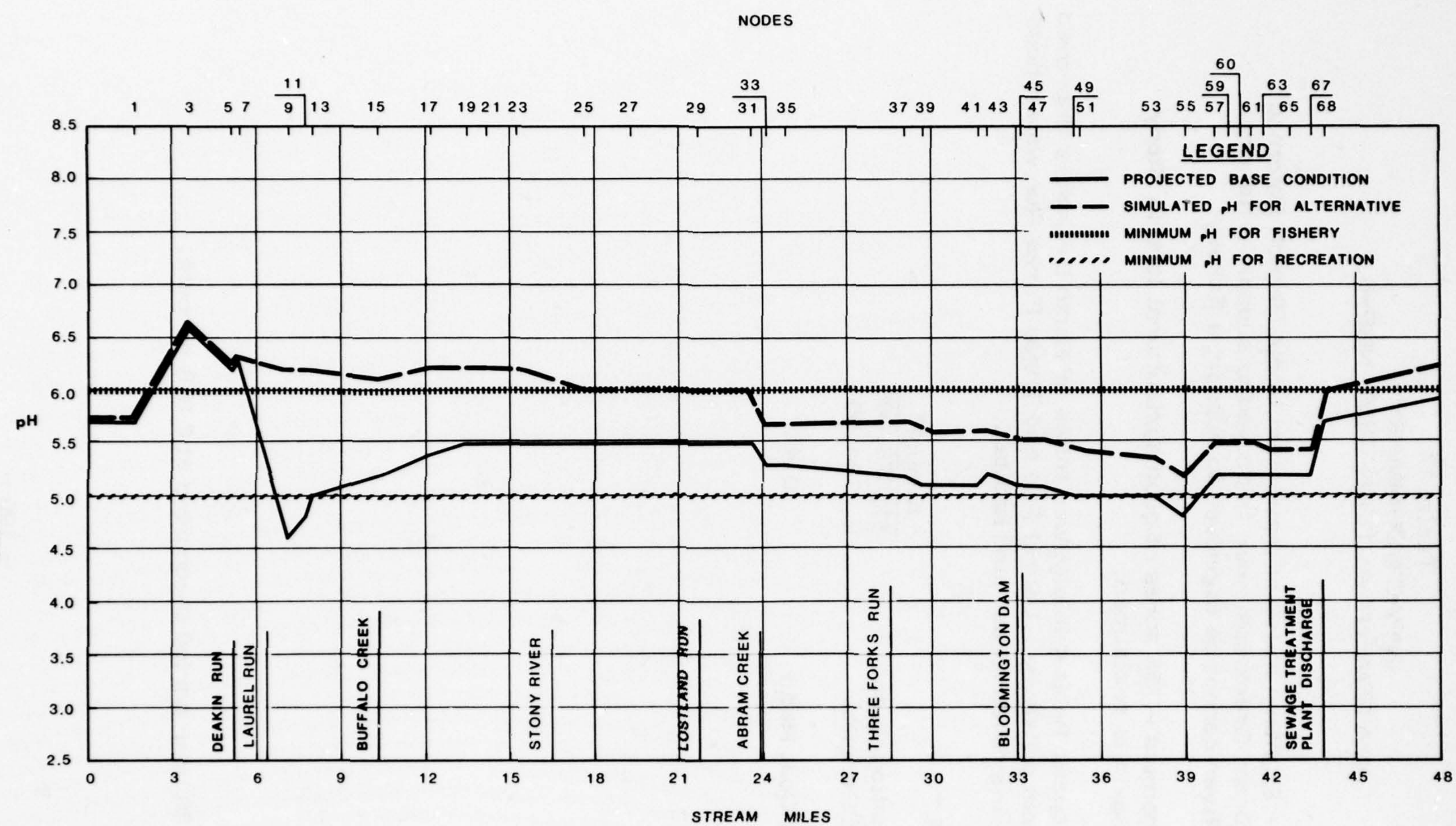
Land Use/Economics - 755 acres of good agricultural land in Stony River Basin is reclaimed.

Ecological - Aquatic habitat in eighteen miles of North Branch is improved to support a fishery. Laurel Run and Three Forks Run watersheds realize improved forest land habitat.

Benefits/Costs -

	Annual*
Reclamation Costs	$1,878,000
Project Benefits	$ 784,000
Benefit Cost Ratio	0.42

*Over 30 year period discounted at 6 3/8 percent.

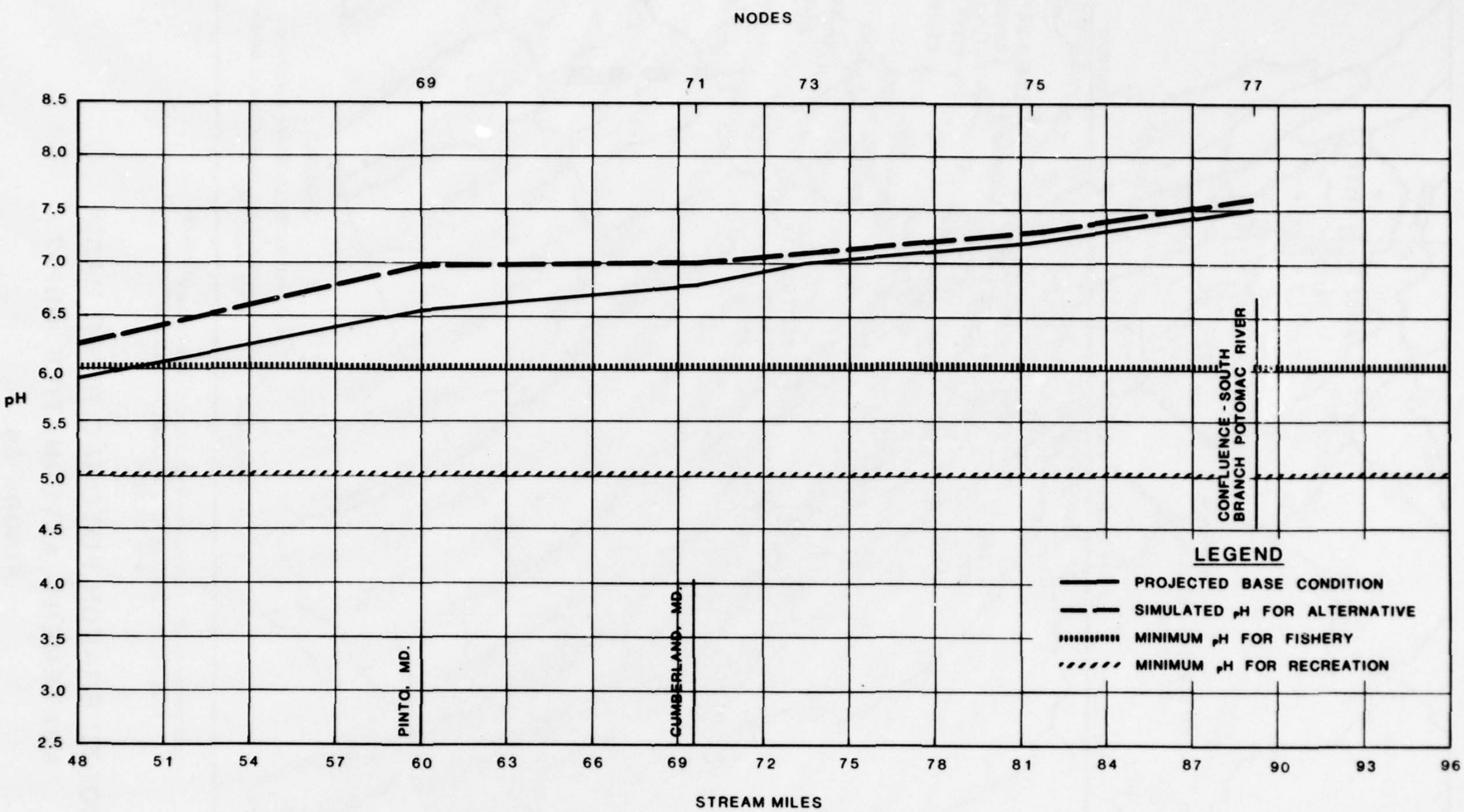


NORTH BRANCH POTOMAC RIVER BASIN

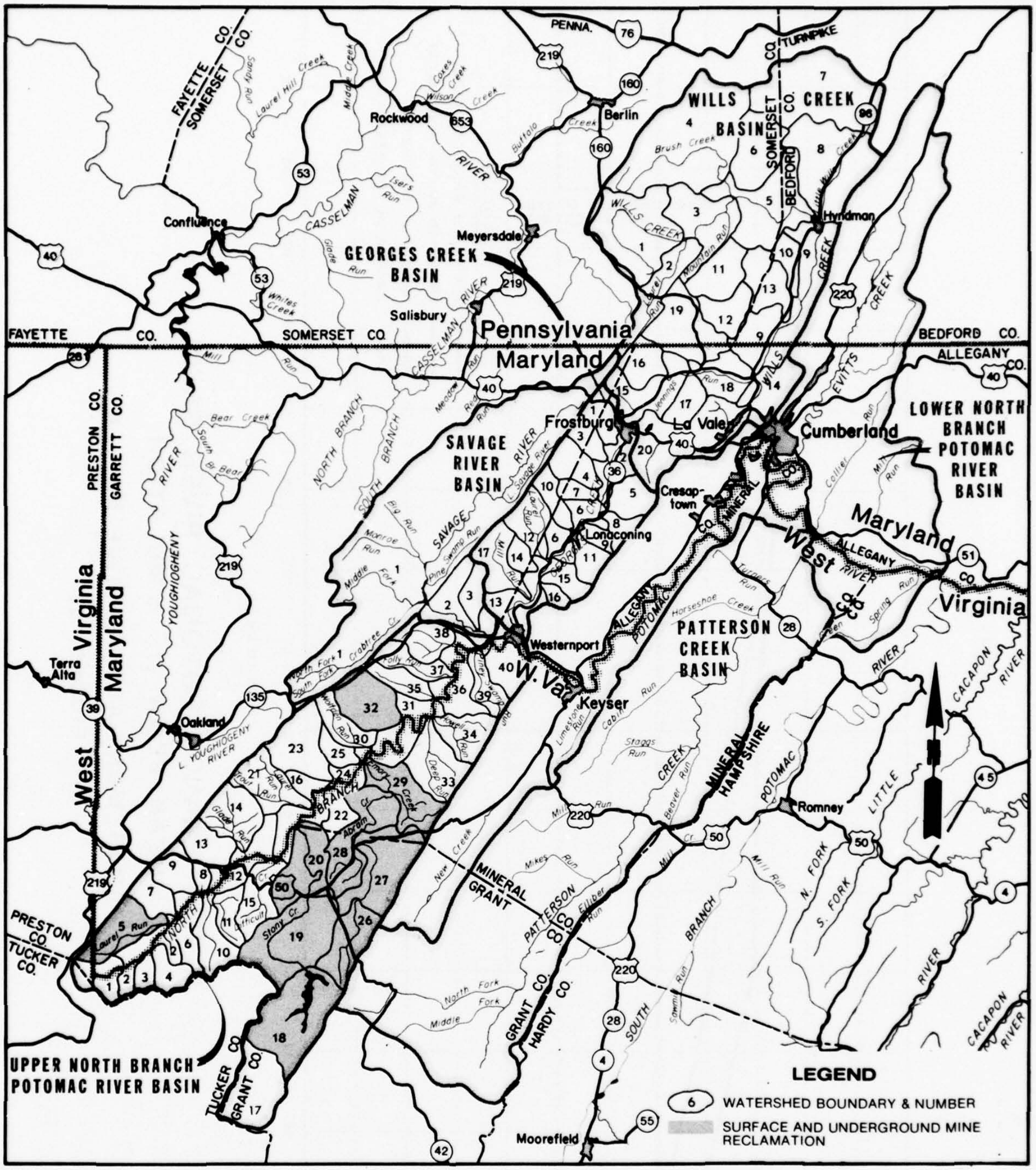
MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP-6

FIGURE 35



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE NBP - 6
FIGURE 35



5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

Scale 1:500,000

NORTH BRANCH POTOMAC RIVER BASIN

ABATEMENT ALTERNATIVE NBP-7

FIGURE 36

Table 18
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-7

Water Quality - 24 miles of main stem North Branch and 14 miles of Abram Creek improved to a pH above 6.0. Bloomington Lake quality raised to pH 5.8.

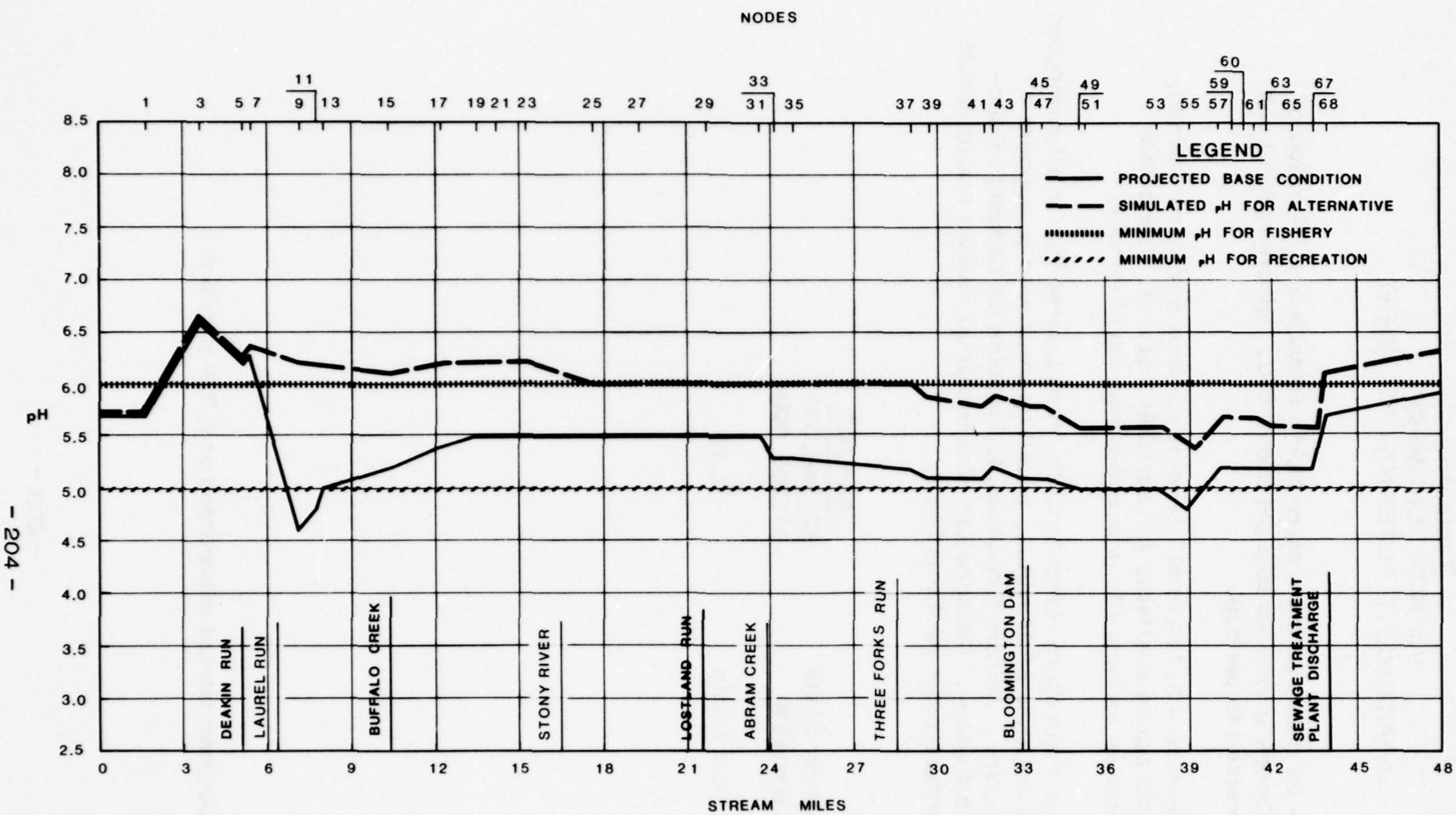
Land Use/Economics - 3,714 total acres of surface mines reclaimed, with 2,205 acres available for agricultural use. Land near Mt. Storm is expected to undergo urban development.

Ecological - The main stem North Branch from Laurel Run to Bloomington Lake, a distance of 24 miles, would be improved to support a sport fishery. Abram Creek would likewise be capable of supporting a fishery. Restoration of terrestrial habitat would result from surface mine reclamation.

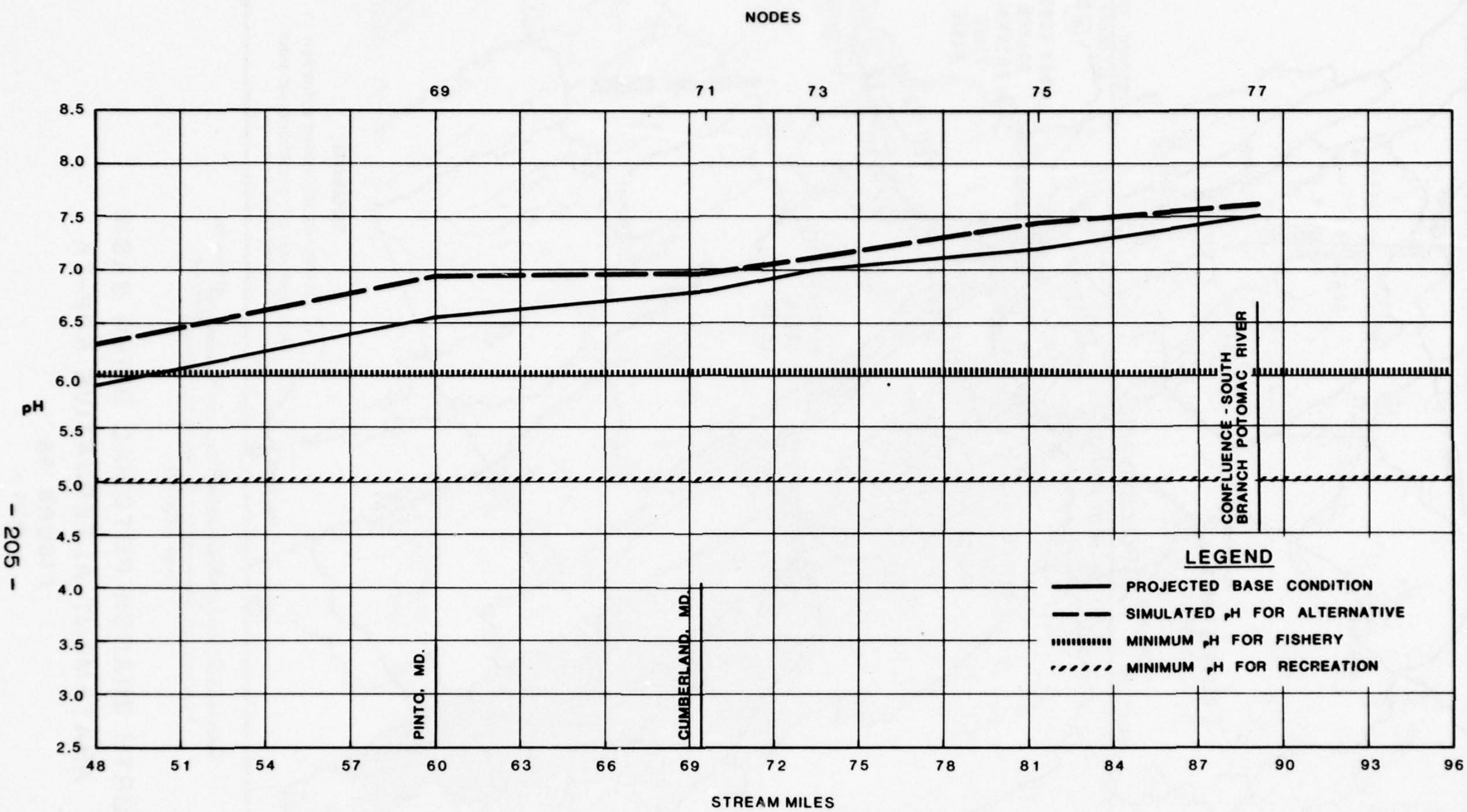
Benefits/Costs -

	Annual*
Reclamation Costs	$2,548,000
Project Benefits	$1,260,000
Benefit Cost Ratio	0.49

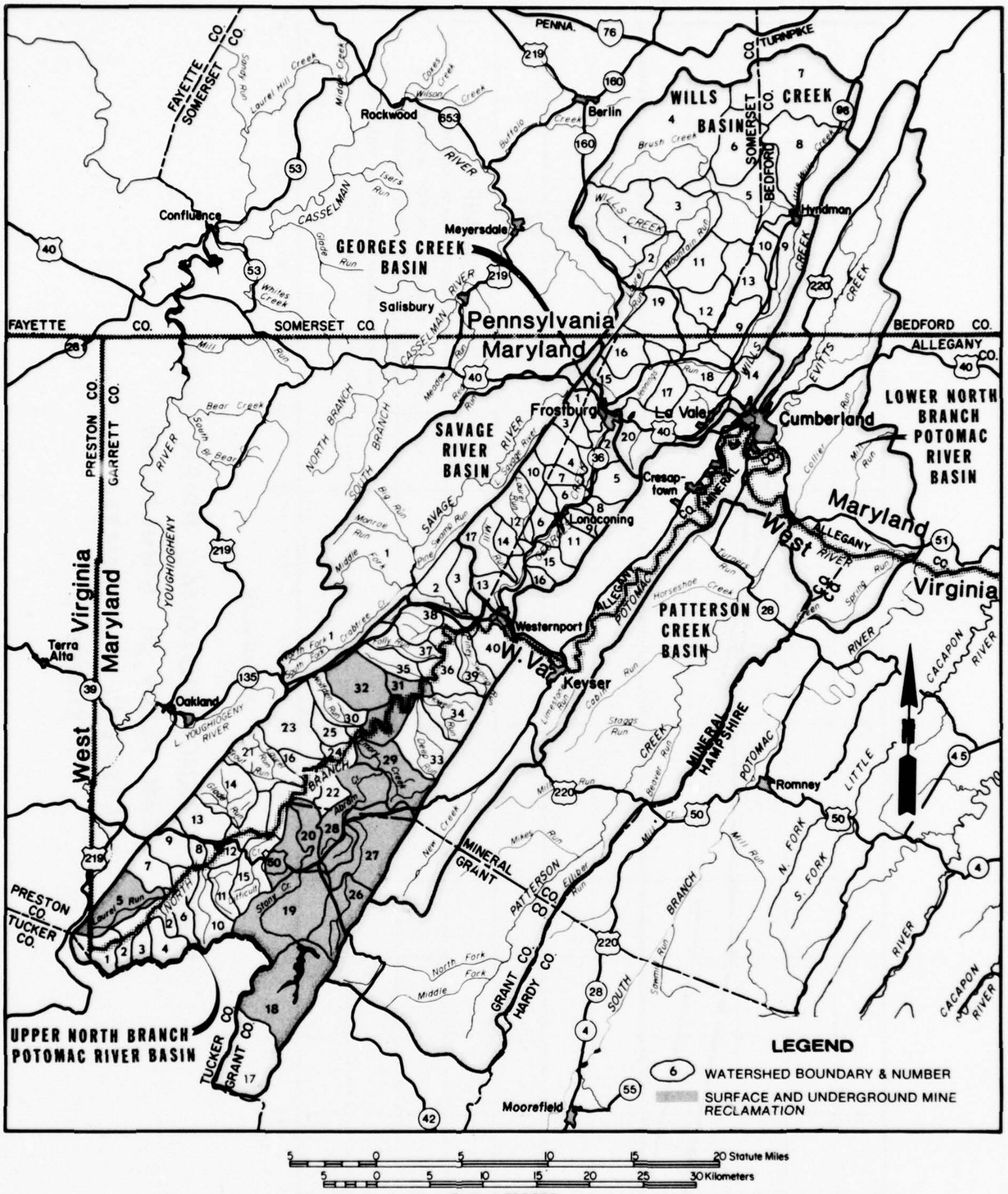
*Over 30 year period discounted at 6 3/8 percent.



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE NBP-7
FIGURE 37



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE 7
FIGURE 37



NORTH BRANCH POTOMAC RIVER BASIN

ABATEMENT ALTERNATIVE NBP-7A

FIGURE 38

Table 19
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-7A

Water Quality - 24 miles of main stem North Branch, 14 miles of Abram Creek, and Bloomington Lake improved to a pH above 6.0.

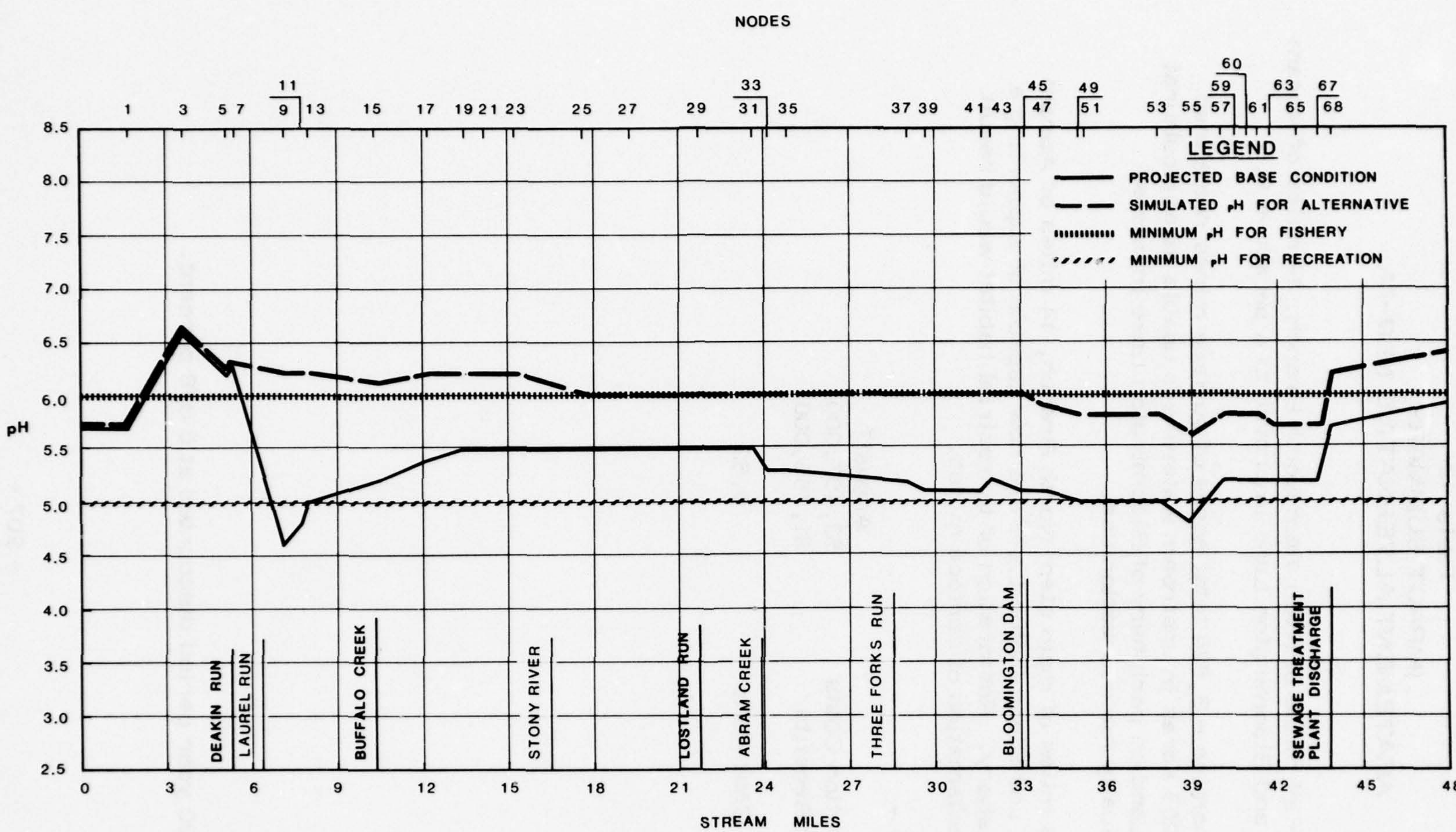
Land Use/Economics - 3,825 total acres of surface mines reclaimed with 2,205 acres in upstream watersheds usable as agricultural land. Land on periphery of Bloomington Lake improved aesthetically for recreation use.

Ecological - 24 miles of main stem North Branch, 14 miles of Abram Creek, and Bloomington Lake are now capable of supporting a sport fishery. Restoration of terrestrial habitat would result from reclamation of surface mines.

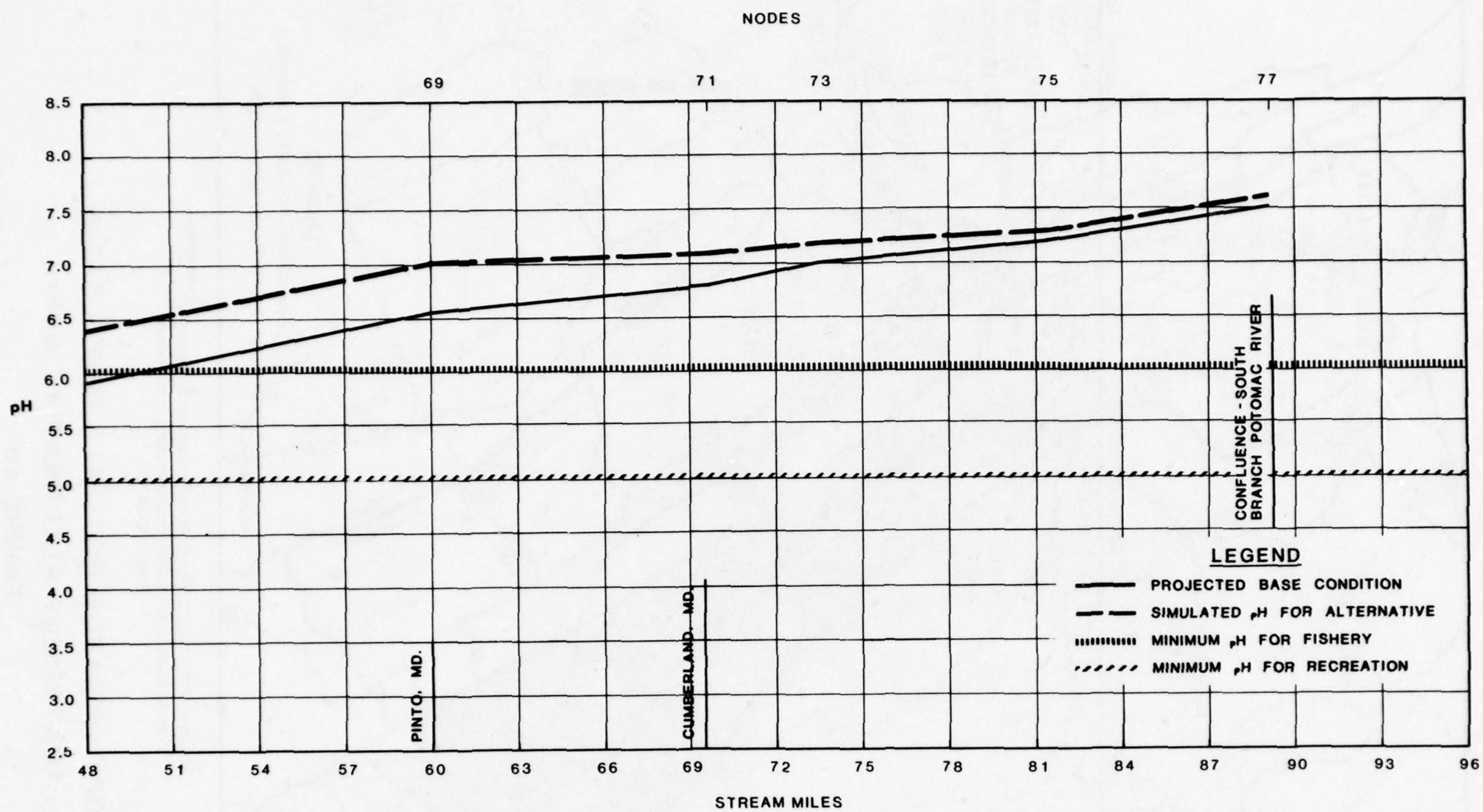
Benefits/Costs -

	Annual*
Reclamation Costs	$3,407,000
Project Benefits	$1,765,000
Benefit Cost Ratio	0.52

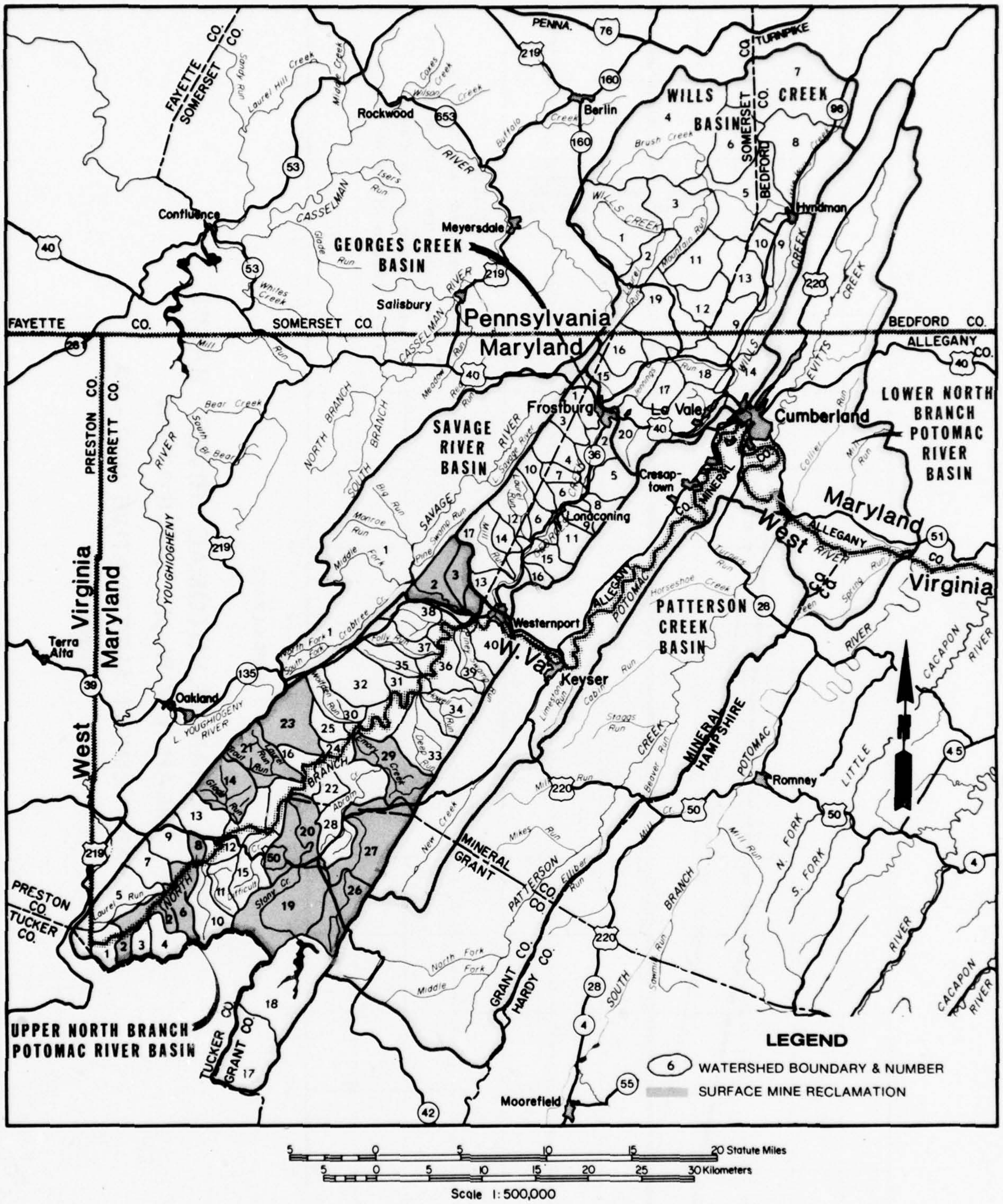
*Over 30 year period discounted at 6 3/8 percent.



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE 7 A
FIGURE 39



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW $_pH$ SIMULATION
ABATEMENT ALTERNATIVE NBP - 7A
FIGURE 39



NORTH BRANCH POTOMAC RIVER BASIN

ABATEMENT ALTERNATIVE NBP-8

FIGURE 40

Table 20
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-8

Water Quality - No water quality changes will occur as a result of this plan.

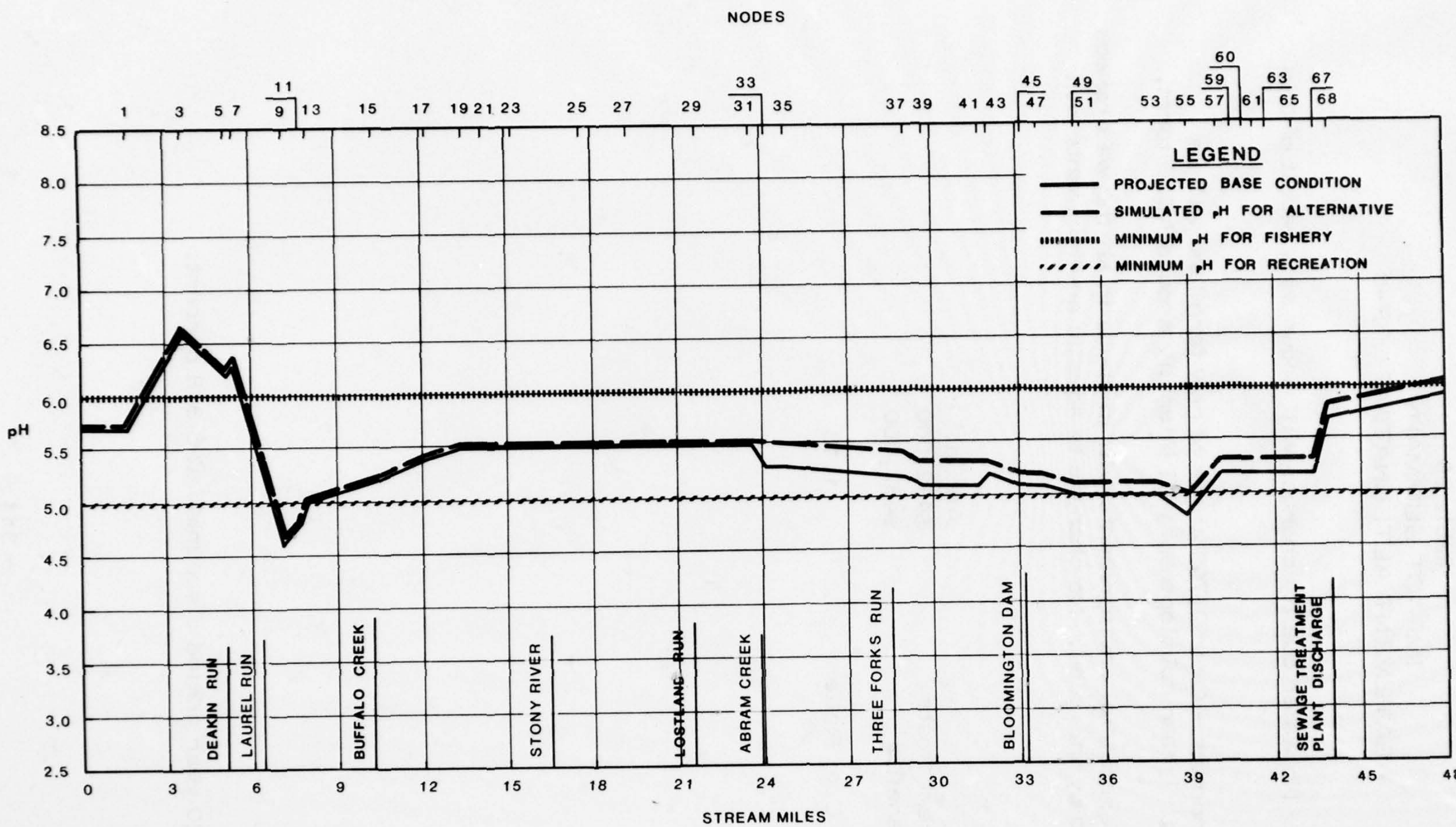
Land Use/Economics - Over 2,700 acres of new farmland will be created. Urban development will intensify around Mt. Storm.

Ecological - Terrestrial environments will improve in all the watersheds affected by this plan. No changes to aquatic environments will occur.

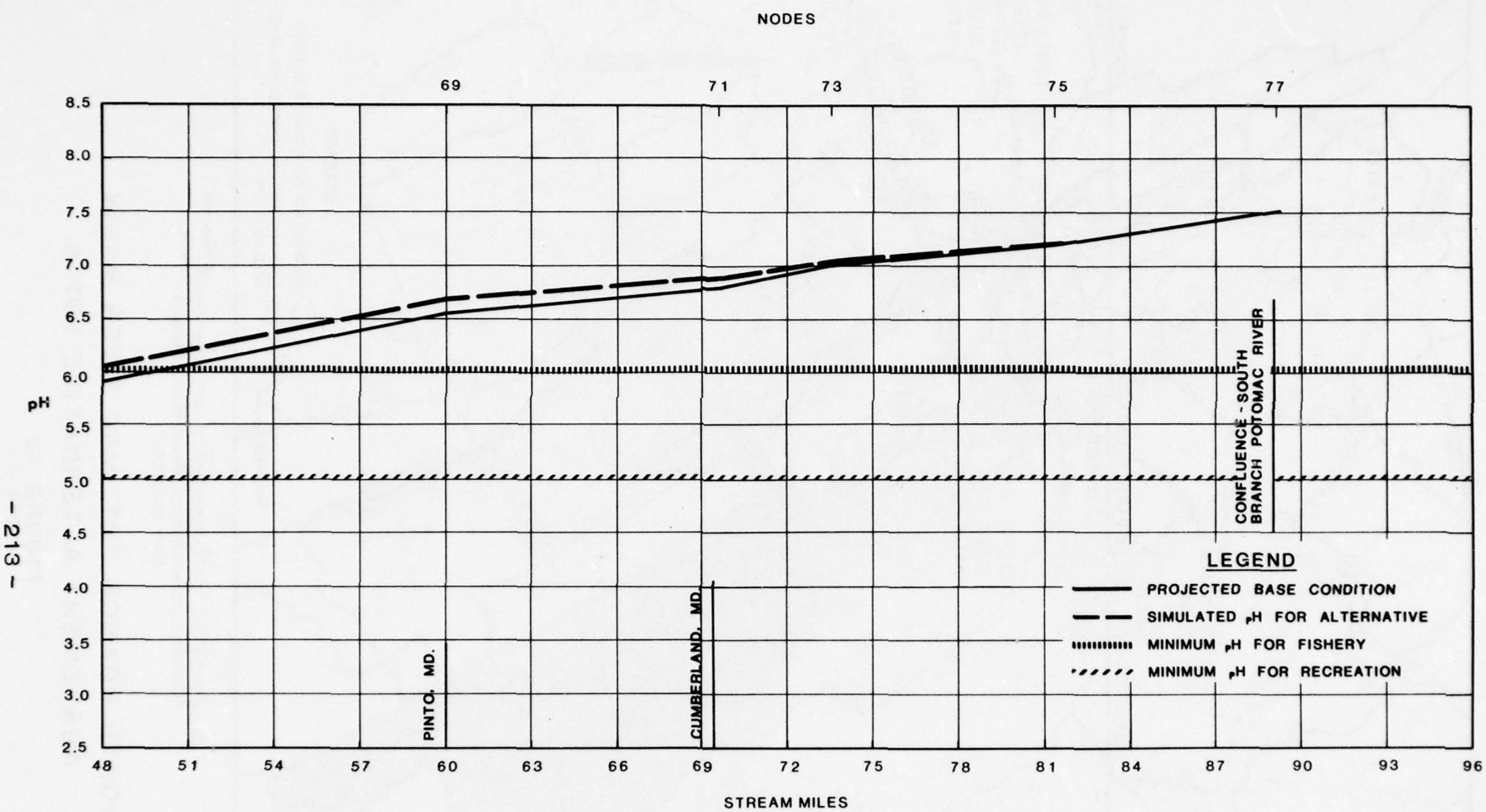
Benefits/Costs -

	Annual*
Abatement Costs	$412,000
Plan Benefits	$487,000
Benefit Cost Ratio	1.16

*Over 30 year period discounted at 6 3/8 percent.



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW $_pH$ SIMULATION
ABATEMENT ALTERNATIVE NBP - 8
FIGURE 41

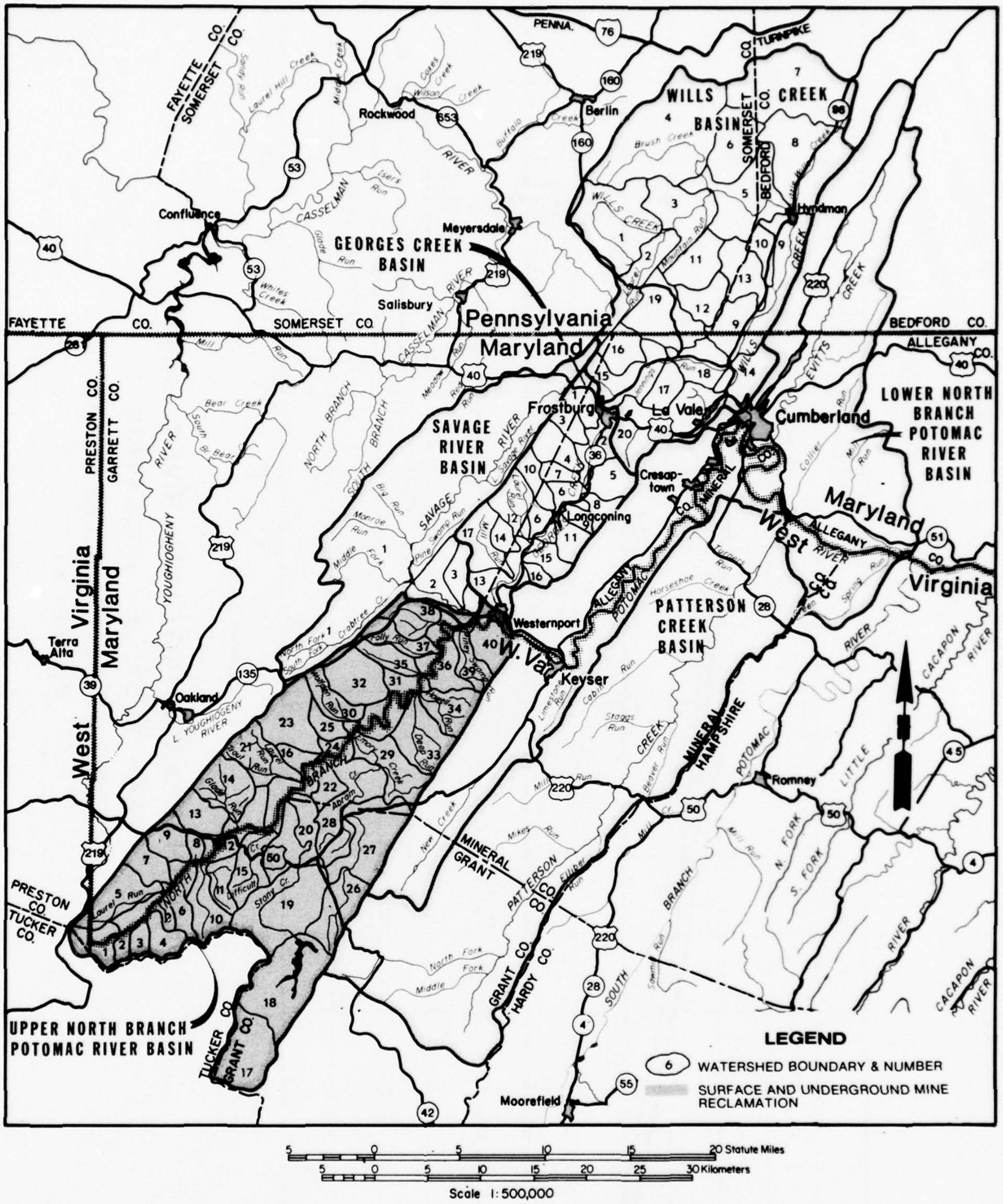


NORTH BRANCH POTOMAC RIVER BASIN

MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP - 8

FIGURE 41



NORTH BRANCH POTOMAC RIVER BASIN
ABATEMENT ALTERNATIVE NBP-9

FIGURE 42

Table 21
IMPACT SUMMARY
ABATEMENT ALTERNATIVE NBP-9

Water Quality - 39 miles of main stem North Branch, and Bloomington Lake improved to pH of 6.0 or greater. 15 miles of main stem downstream from Bloomington Lake improved as a result of abatement of tributaries downstream.

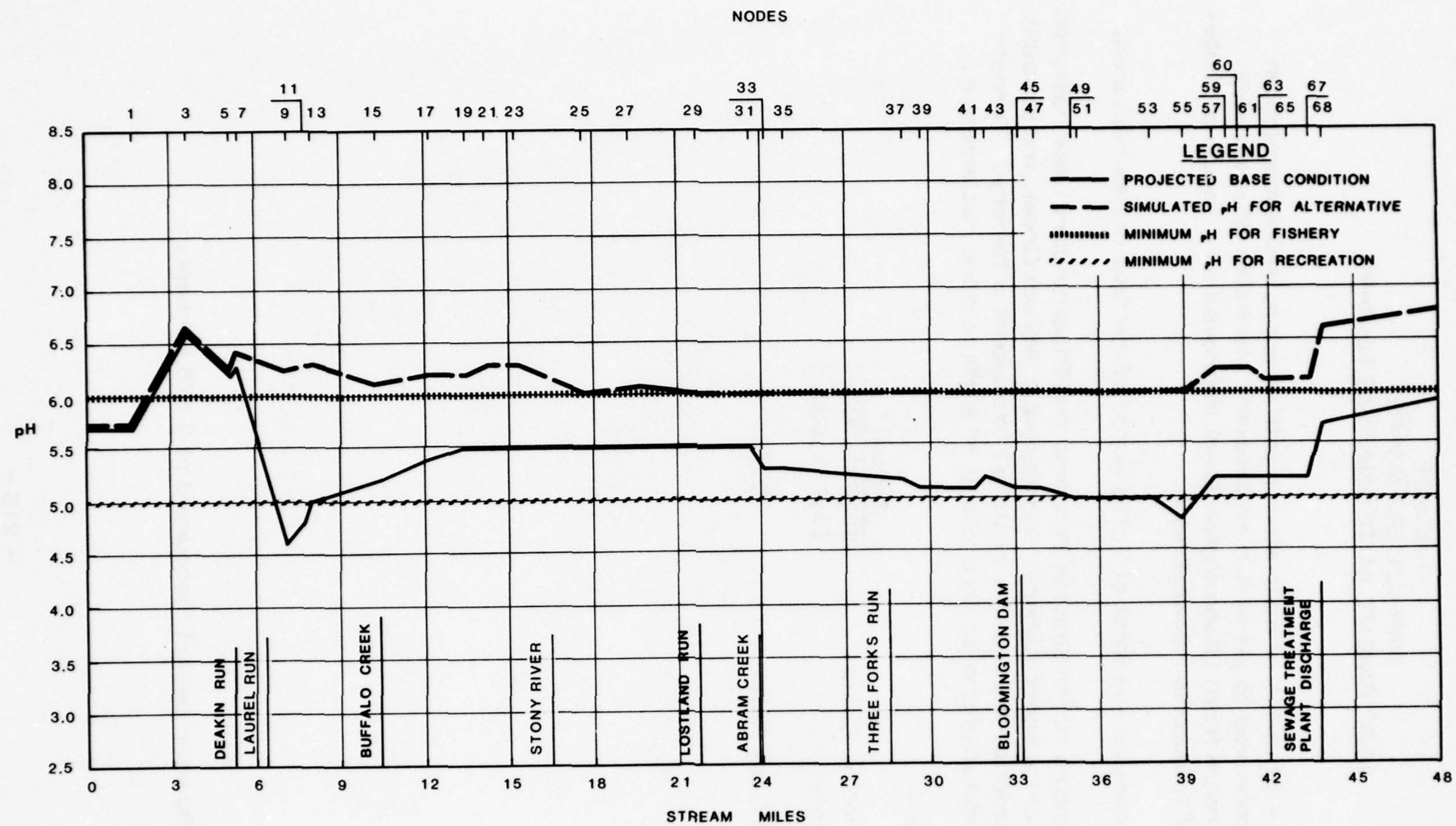
Land Use/Economics - A total of 7,781 acres of surface mines restored.

Ecological - Entire North Branch Potomac and Bloomington Lake restored to support a sport fishery. Additionally Abram Creek and possibly other smaller tributaries restored to support a fishery. Terrestrial habitat improved as a result of surface mine reclamation.

Benefits/Costs -

	Annual*
Reclamation Costs	$5,831,000
Plan Benefits	$2,792,000
Benefit Cost Ratio	0.48

*Over 30 year period discounted at 6 3/8 percent.

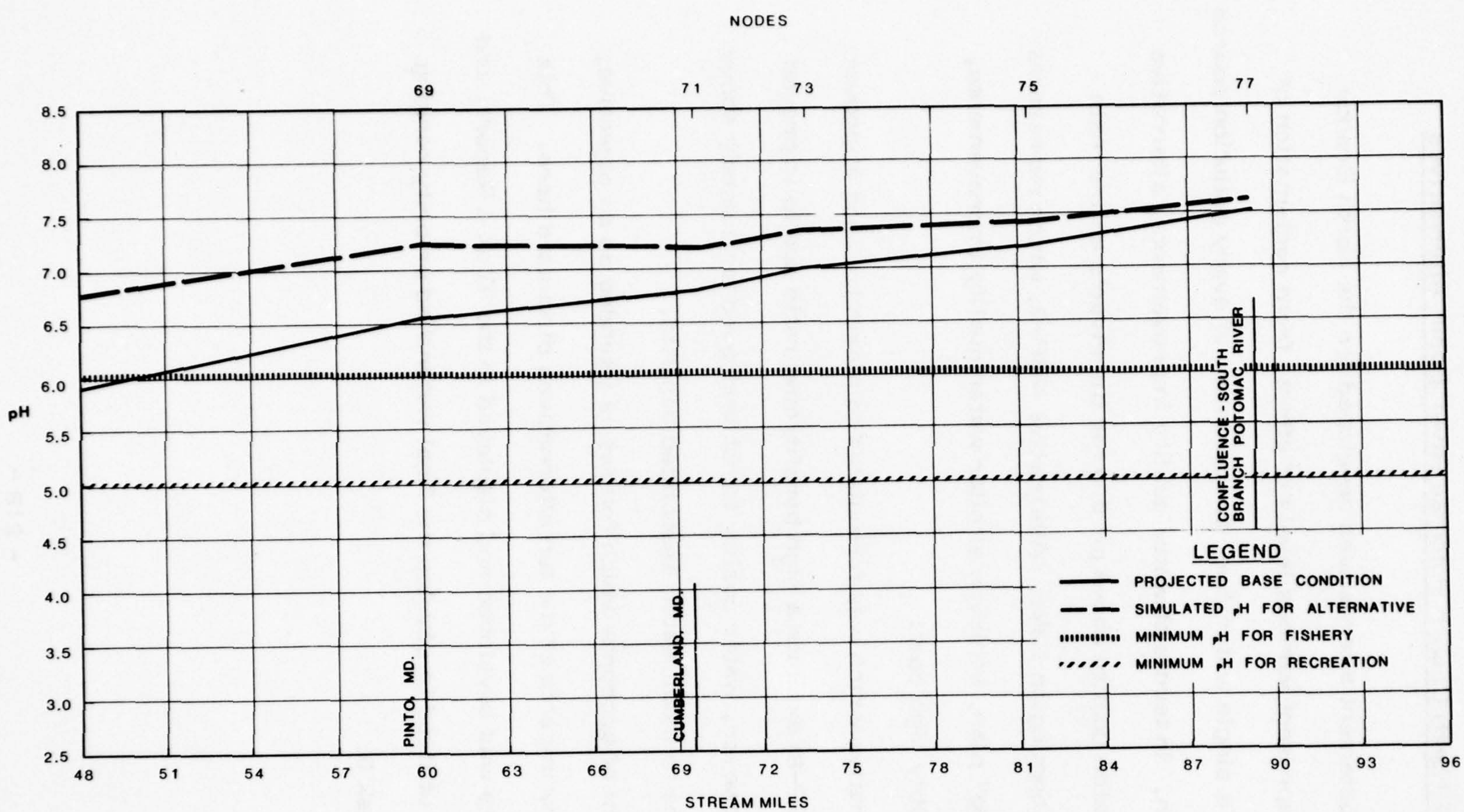


NORTH BRANCH POTOMAC RIVER BASIN

MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE NBP - 9

FIGURE 43



NORTH BRANCH POTOMAC RIVER BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE NBP - 9
FIGURE 43

Summary of North Branch Potomac River Basin Alternatives

The ten abatement alternatives developed for the North Branch Potomac River represent various levels of effort, from reclamation of surface mines in a single watershed, to abatement of every pollution source in the entire basin. In terms of water quality improvements, alternative NBP-7A yields water quality above pH 6.0 for the river's entire main stem including Bloomington Lake. Alternative NBP-9, which represents the "do-everything" plan, achieves similar water quality improvements, but at a considerably high cost.

The alternative which was formulated to maximize land improvement benefits (NBP-8) exhibits a high benefit/cost ratio due to improved land benefits. However, water quality is not improved sufficiently above baseline conditions to incur water associated benefits.

The system of accounts which follows is intended as an objective, vivid display of the impacts of the ten alternatives discussed here. This system of accounts was developed and displayed in the Task 4 Report, and was subsequently utilized to develop the final watershed priority ranking system during Task 5.

Environmental Quality Account

The Environmental Quality (EQ) Account is intended as a comparative display of the impacts of each plan upon some basic environmental considerations. Any of the reclamation plans will have some positive impact upon the quality of the terrestrial environment by reclaiming abandoned surface mines. The relative values assigned land quality improvement in the EQ Account are based upon the number of acres restored and their potential use. Relative values for water habitat improvement were similarly assigned by considering the number of stream miles improved for fishing and aesthetic enjoyment. Air quality will improve as a result of land reclamation, due to reduced generation of fugitive particulate matter, and the values assigned this benefit were based upon acres of land restored.

The tabulated Environmental Quality Account appears on page 222.

TABLE 22

NATIONAL ECONOMIC DEVELOPMENT AND REGIONAL

ABATEMENT PLAN	ANNUAL COST	RECLAIMED ACRES	LAND ORIENTED BENEFITS (ANNUAL)								
			AGRICULTURE		TIMBER		HUNTING		AESTHETICS/ RECREATION		EMPLOYMENT
			ACRES	$ VALUE	ACRES	$ VALUE	ACRES	$ VALUE	ACRES	$ VALUE	$ VALUE
NBP - 1 Watersheds 18, 19, 20	$ 412,000	1,487	755	75,500	702	3,510	1,457	25,643	981	12,066	124,000
NBP - 2 Watersheds 26, 27, 28, 29	669,000	1,671	1,450	145,000	221	1,105	1,671	29,409	221	2,718	201,000
NBP - 3 Watersheds 5	940,000	367	0	0	367	1,835	367	6,459	367	4,514	282,000
NBP - 4 Watersheds 5, 32	1,466,000	556	0	0	556	2,780	556	9,785	556	6,839	440,000
NBP - 5 Watersheds 5, 32, 26, 27, 28, 29	2,135,000	2,227	1,450	145,000	777	3,885	2,227	39,194	777	9,557	641,000
NBP - 6 Watersheds 5, 32, 18, 19, 20	1,878,000	2,043	755	75,500	1,258	6,290	2,013	35,428	1,537	18,905	563,000
NBP - 7 Watersheds 5, 32, 18, 19, 20, 26, 27, 28, 29	2,548,000	3,714	2,205	220,500	1,479	7,395	3,684	64,838	1,758	21,623	764,000
NBP - 7A Watersheds 18, 19, 20, 26, 27, 28, 29, 5, 32, 31	3,407,000	3,825	2,205	220,500	1,590	7,950	3,795	66,792	1,869	22,988	1,022,000
NBP - 8 Watersheds 2, 6, 8, 14, 19, 20, 21, 23, 26, 27, 29, SR-2, SR-3	412,000	4,230	2,729	272,900	1,171	5,855	3,900	68,640	1,450	17,835	124,000
NBP - 9 All Watersheds	5,831,000	7,781	2,934	293,400	4,817	24,085	7,751	136,417	5,096	62,680	1,749,000

TABLE 22

DEVELOPMENT ACCOUNT-NORTH BRANCH POTOMAC RIVER BASIN

LAND VALUE		TOTAL ANNUAL LAND BENEFITS	WATER ORIENTED BENEFITS (ANNUAL)					TOTAL ANNUAL WATER BENEFITS	TOTAL ANNUAL BENEFITS	BENEFIT / COST RATIO
			FISHING		NON-FISHING		WATER SUPPLY			
ACRES	$VALUE		MILES	$VALUE	MILES	$VALUE	$VALUE			
30	1,500	$ 242,000	0	0	0	0	0	$ 0	$ 242,000	0.59
0	0	379,000	14 AC	63,980	14 AC	6,300	0	70,280	449,000	0.67
0	0	295,000	11 NBP	60,170	0	0	0	60,170	355,000	0.38
0	0	460,000	11 NBP	60,170	0	0	0	60,170	520,000	0.36
0	0	839,000	11 NBP 14 AC	60,170 63,980	0 14 AC	6,300	0 0	130,450	969,000	0.45
30	1,500	702,000	18 NBP	82,260	0	0	0	82,260	784,000	0.42
30	1,500	1,080,000	24 NBP 14 AC	109,680 63,980	14 AC	6,300	0	179,960	1,260,000	0.49
30	1,500	1,343,000	24 NBP 19348B* 14 AC	109,680 121,892 63,980	0 24012B* 14 AC	0 120,060 6,300	0 0 0	421,912	1,765,000	0.52
30	1,500	487,000	0	0	0	0	0	0	487,000	1.16
30	1,500	2,266,000	39 NBP 14 AC 19348B*	213,330 63,980 121,892	0 14 AC 24012B*	0 6,300 120,060	0 0 0	525,562	2,792,000	0.48

*Activity Days (See Plan Assessment Narrative)

NBP = North Branch Potomac River
AC = Abram Creek
B = Bloomingston Lake

TABLE 23

ENVIRONMENTAL QUALITY ACCOUNT
NORTH BRANCH POTOMAC RIVER BASIN

PLAN	ENVIRONMENTAL CONSIDERATIONS						
	AQUATIC HABITAT	AESTHETICS (WATER RELATED)	TERRESTRIAL HABITAT	AESTHETICS (LAND RELATED)	SOIL EROSION CONTROL	AIR QUALITY	TOTAL
NBP-1	0	+1	+1	+1	+1	0	+4
NBP-2	+1 AC	+1 AC	+1	+1	+1	0	+5
NBP-3	+1 NBP	+1 NBP	+1/2	+1/2	+1	0	+4
NBP-4	+1 NBP	+1 NBP	+1/2	+1/2	+2	+1	+6
NBP-5	+1 NBP +1 AC	+1 NBP +1 AC	+2	+2	+2	+1	+11
NBP-6	+2 NBP +1 AC	+2 NBP +1 AC	+2	+2	+2	+1	+13
NBP-7	+3 NBP +1 AC	+3 NBP +1 AC	+3	+3	+3	+2	+19
NBP-7A	+3 NBP +1 AC +2 B	+3 NBP +1 AC +2 B	+3	+3	+3	+2	+23
NBP-8	0	0	+4	+4	+4	+3	+15
NBP-9	+4 NBP +1 AC +2 B	+4 NBP +1 AC +2 B	+6	+6	+4	+3	+33

NBP - NORTH BRANCH POTOMAC RIVER
AC - ABRAM CREEK
B - BLOOMINGTON LAKE

Social Well-Being Account

This account evaluates elements of social well-being with respect to each abatement alternative. The income distribution category shown below is related directly to cost, since the greater the cost of the project, the more employment opportunities will be created. Given the high, persistent unemployment levels in the region, these plans will significantly improve the income position of lower income individuals who are unemployed. Thus, those plans with higher costs are rated with a greater number of pluses.

Only three plans are shown to significantly improve the health and safety of the residents of the basin. These plans create a large amount of new agricultural land in the basin, thus increasing the amount of locally-grown foodstuffs.

Under the educational, cultural, and recreational opportunities category, only recreational opportunities improve with the introduction of each plan. A plus was given if the plan created land-oriented recreational opportunities, if it created water-oriented recreational opportunities, or if it created recreational opportunities in Bloomington Lake. Thus, if a plan created recreational opportunities in all three categories, it would receive three pluses.

No plan significantly affects emergency preparedness. The total columns sum the number of pluses for each plan. Plans NBP 7A and NBP 10 are superior to all others basically because they maximize recreational opportunities.

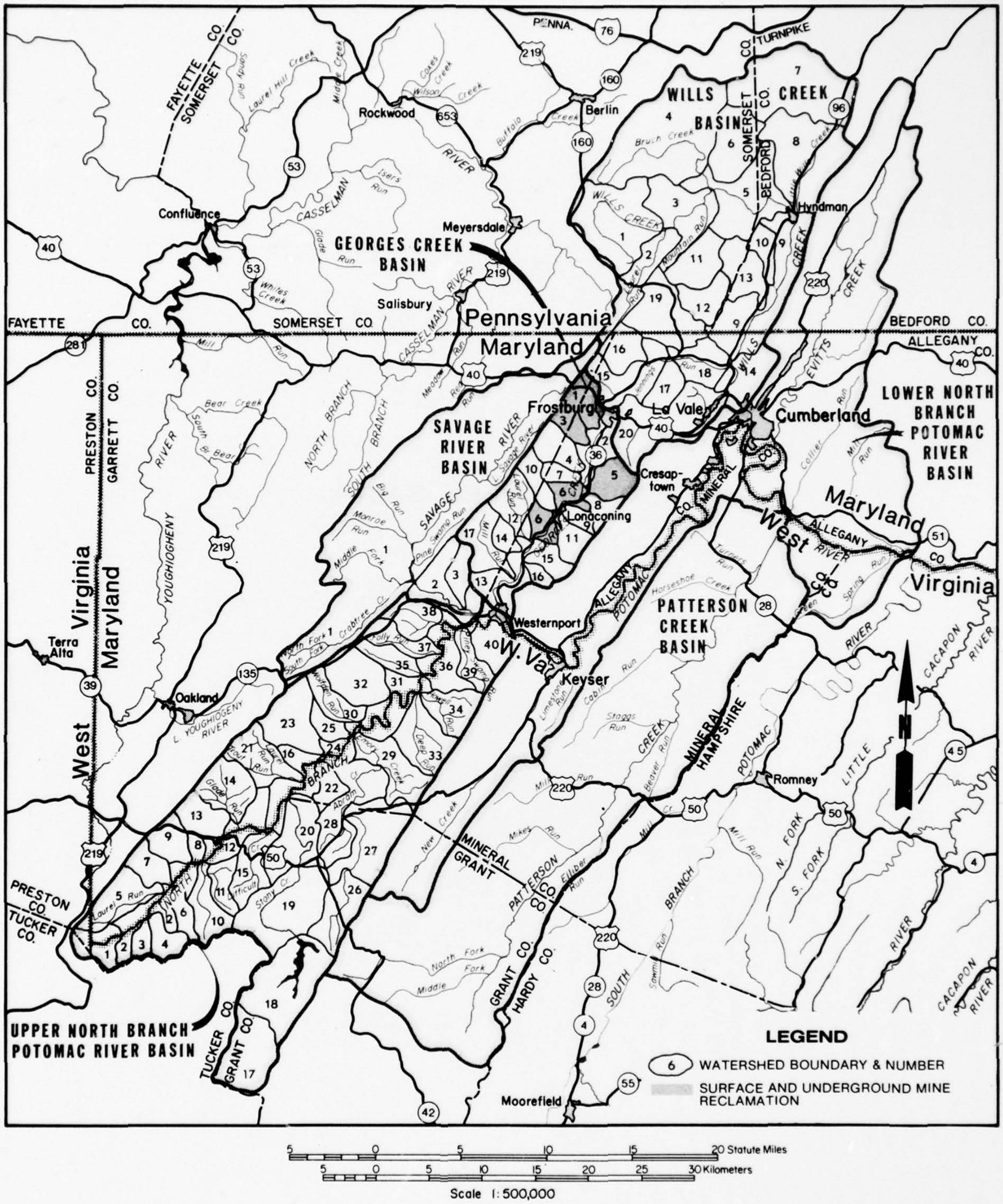
The Social Well-Being Account follows.

TABLE 24

SOCIAL WELL-BEING ACCOUNT
NORTH BRANCH POTOMAC RIVER BASIN

PLAN	SOCIAL WELL-BEING CONSIDERATIONS				
	INCOME DISTRIBUTION	HEALTH & SAFETY	EDUCATIONAL, CULTURAL & RECREATIONAL OPPORTUNITIES	EMERGENCY PREPAREDNESS	TOTAL
NBP-1	+1	0	+1	0	+2
NBP-2	+1	0	+2	0	+3
NBP-3	+1	0	+2	0	+3
NBP-4	+1	0	+2	0	+3
NBP-5	+2	0	+2	0	+4
NBP-6	+2	0	+2	0	+4
NBP-7	+2	0	+2	0	+4
NBP-7A	+2	0	+3	0	+5
NBP-8	+1	+1	+1	0	+3
NBP-9	+3	+1	+3	0	+7

GEORGES CREEK BASIN



GEORGES CREEK BASIN
ABATEMENT ALTERNATIVE GC-1
FIGURE 44

Table 25
IMPACT SUMMARY
ABATEMENT ALTERNATIVE GC-1

Water Quality - Increase in pH is not significant (much of Georges Creek is already above pH 6.0). Stream degradation is due primarily to municipal effluents.

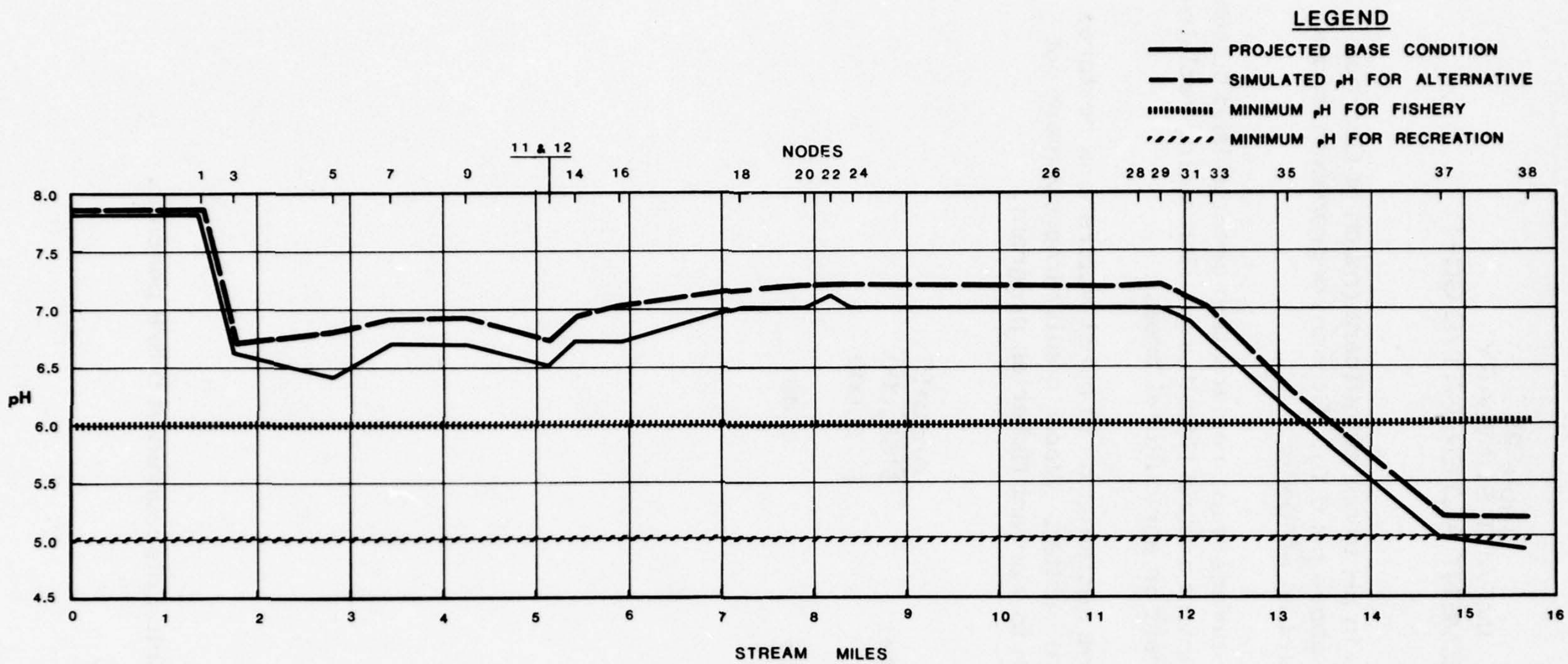
Land Use/Economics - Surface mine reclamation creates land suitable for urban development around Frostburg. Remaining reclaimed land useful as forest or agricultural area.

Ecological - Surface mine reclamation in rural watersheds restores natural terrestrial habitat. Water quality improvement not significant enough to warrant fisheries program.

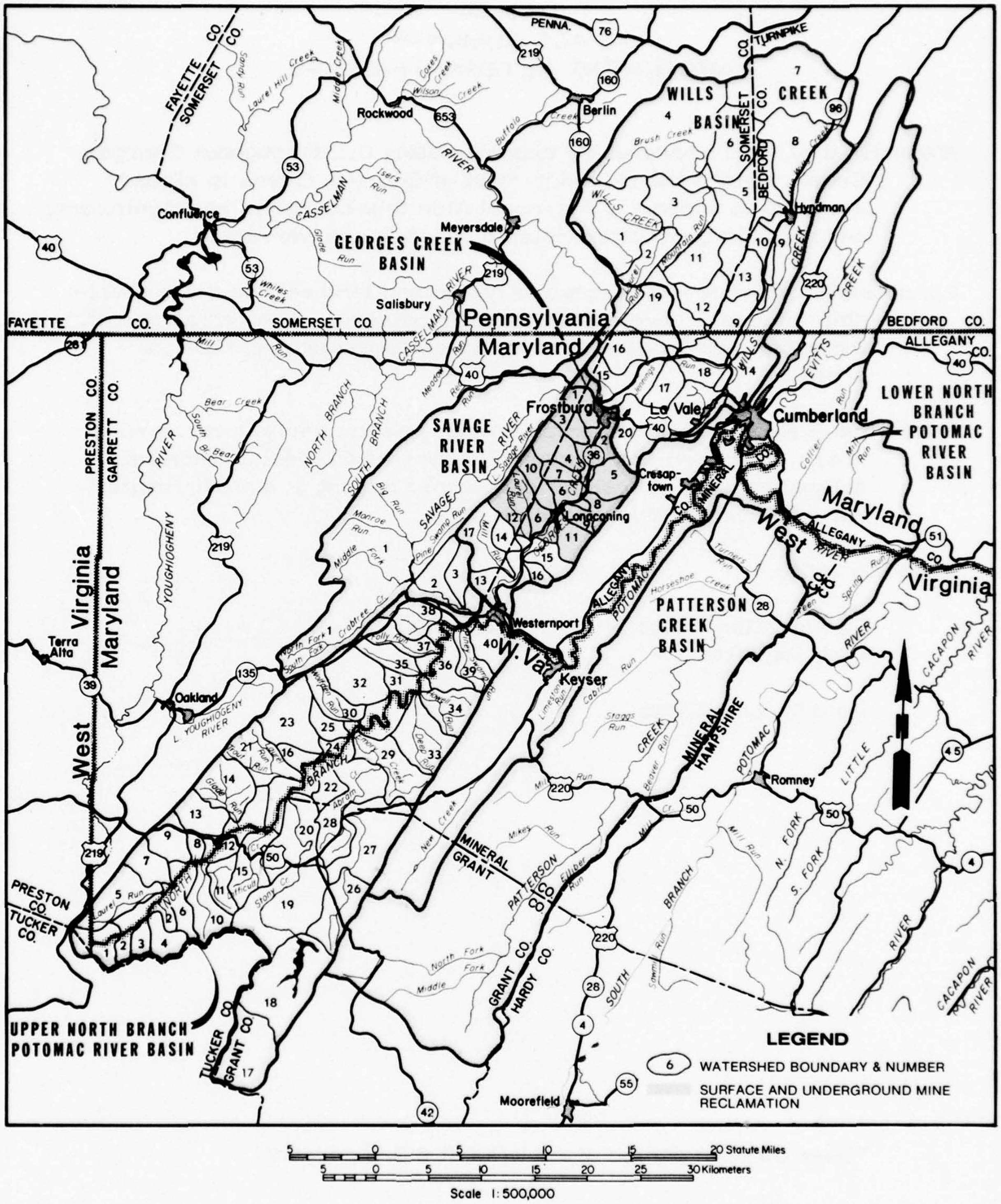
Benefits/Costs -

	Annual*
Reclamation Costs	$153,000
Plan Benefits	$ 70,000
Benefit/Cost Ratio	0.46

*Over 30 year period discounted at 6 3/8 percent.



GEORGES CREEK BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE GC-1
FIGURE 45



GEORGES CREEK BASIN
ABATEMENT ALTERNATIVE GC-2

FIGURE 46

Table 26
IMPACT SUMMARY
ABATEMENT ALTERNATIVE GC-2

Water Quality - pH improves by approximately 0.2 throughout Georges Creek. Since the pH along most of Georges Creek is already adequate to support a fish population this change is not significant, and no additional water-related benefits are warranted.

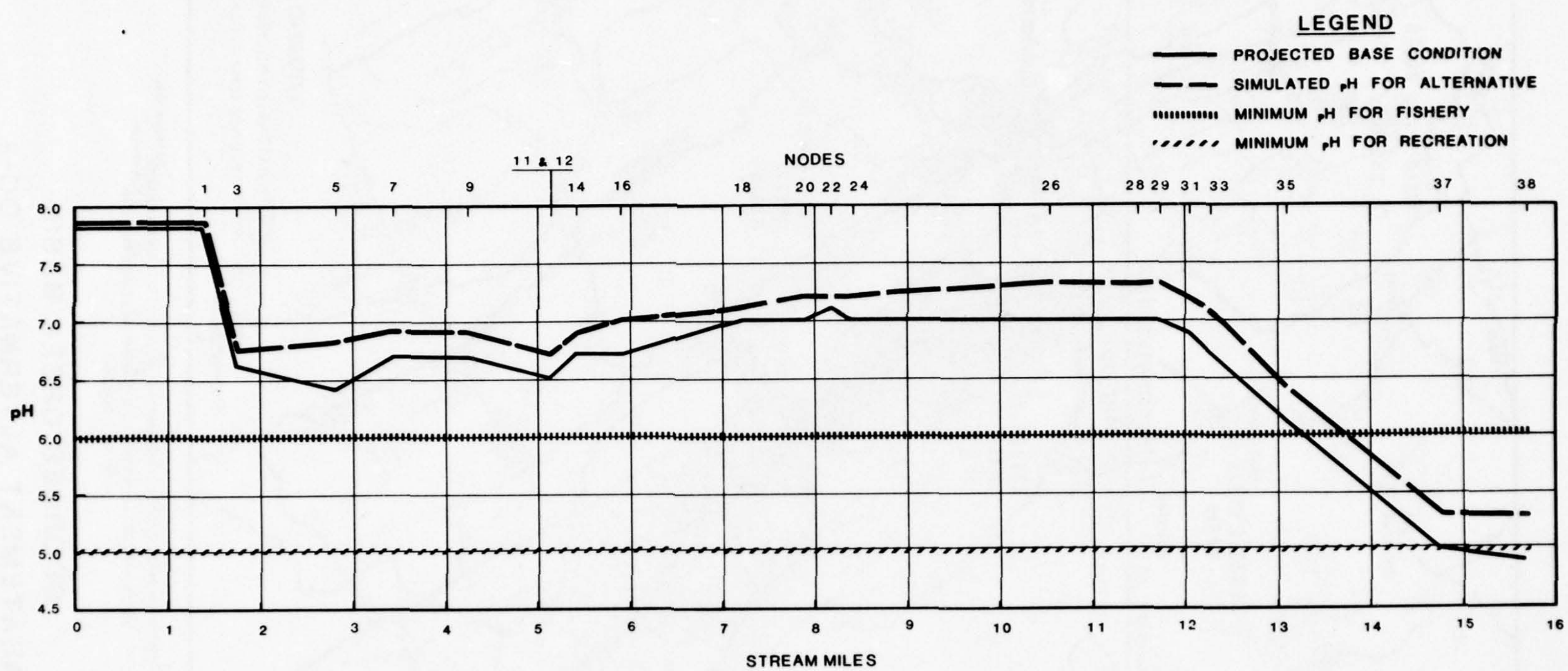
Land Use/Economics - 295 acres of reclaimed land will be made available for urban development near Frostburg. The remainder of the reclaimed land reverts to use as forest and recreation areas.

Ecological - Reclamation of surface mines, particularly in more rural areas in eastern and western portions of the basin, improves natural habitat. No significant improvement in aquatic habitat will result from this alternative.

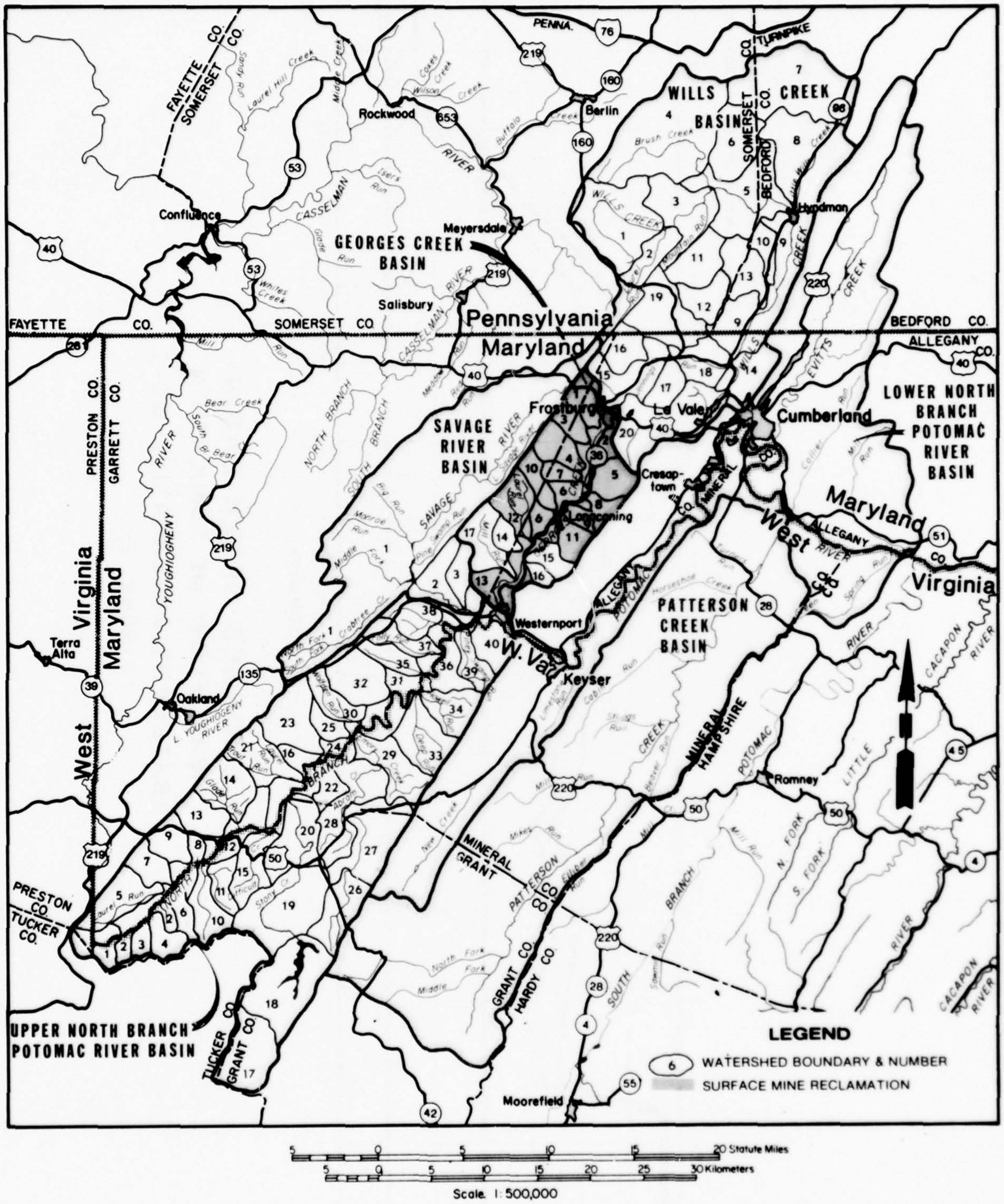
Benefits/Costs -

	Annual*
Reclamation Costs	$650,000
Plan Benefits	$284,000
Benefit/Cost Ratio	0.38

*Over 30 year period discounted at 6 3/8 percent.



GEORGES CREEK BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE GC-2
FIGURE 47



GEORGES CREEK BASIN
ABATEMENT ALTERNATIVE GC-3
FIGURE 48

Table 27
IMPACT SUMMARY
ABATEMENT ALTERNATIVE GC-3

Water Quality - Very slight improvement in pH. Not significant in creating any new water-related benefits.

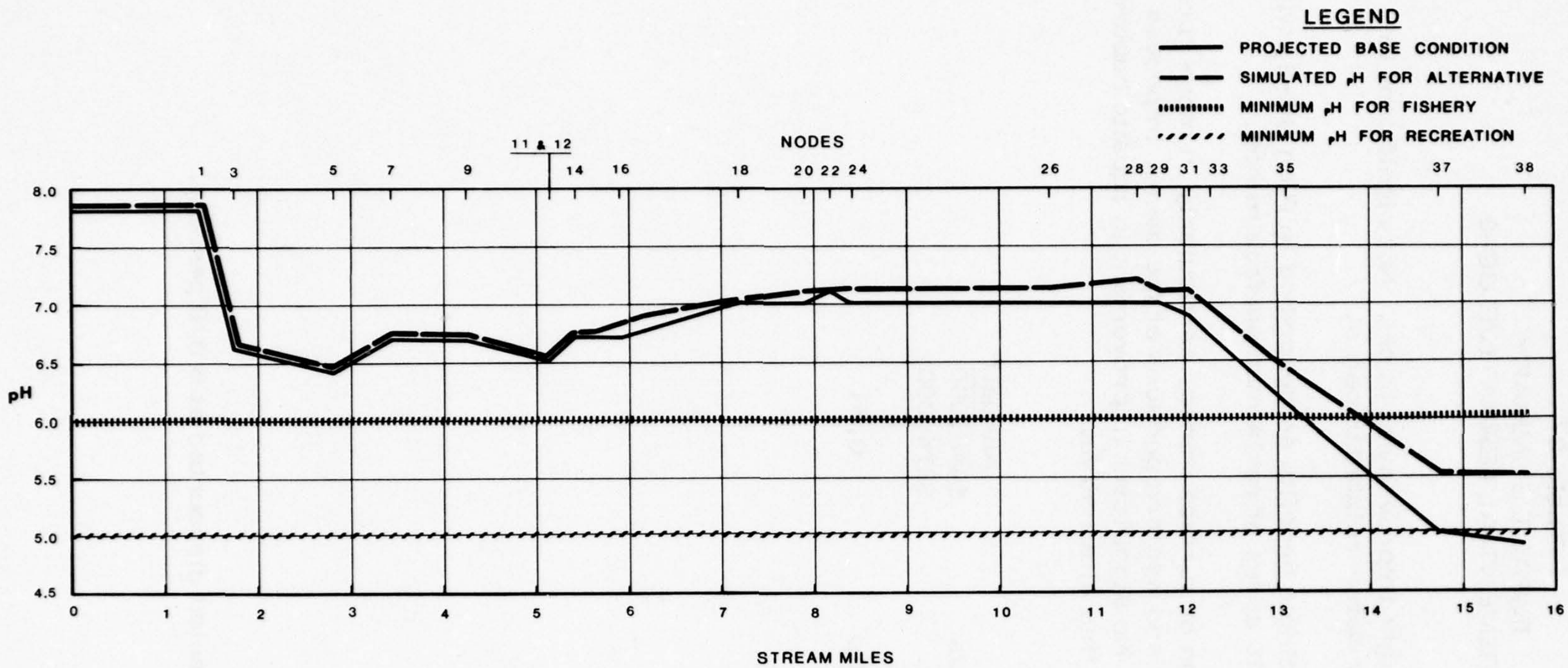
Land Use/Economics - Same benefits as described in Plan GC-2, with the addition of 718 acres of reclaimed surface mines.

Ecological - Reclamation of surface mines, particularly in more rural areas in eastern and western portions of the basin, improves natural habitat. No significant improvement in aquatic habitat will result from this alternative.

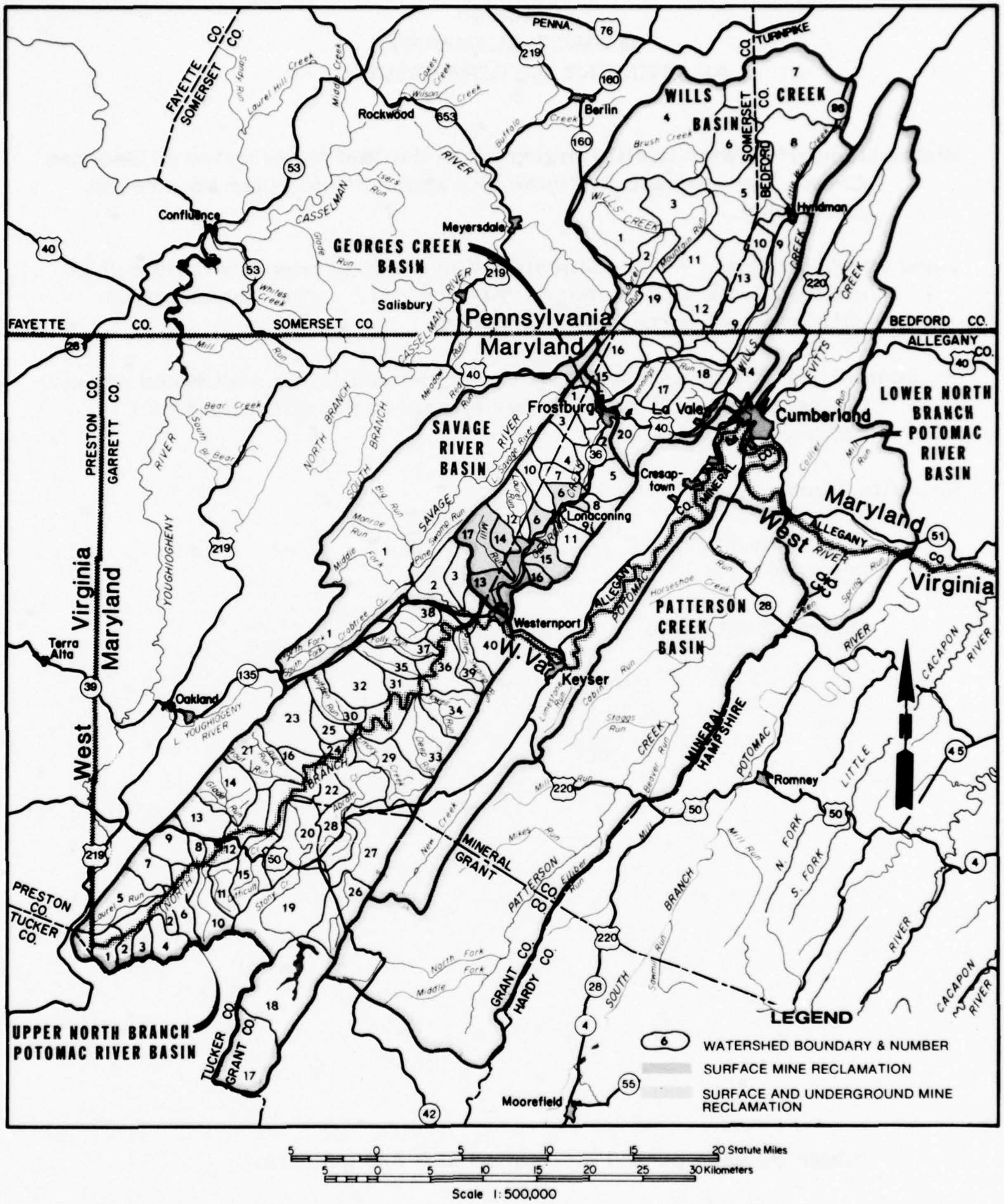
Benefits/Costs -

	Annual*
Reclamation Costs	$448,000
Plan Benefits	$274,000
Benefit/Cost Ratio	0.61

*Over 30 year period discounted at 6 3/8 percent.



GEORGES CREEK BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE GC - 3
FIGURE 49



GEORGES CREEK BASIN
ABATEMENT ALTERNATIVE GC-4
FIGURE 50

Table 28
IMPACT SUMMARY
ABATEMENT ALTERNATIVE GC-4

Water Quality – Water quality improves in the last three miles of Georges Creek. pH exceeds 6.2 over this reach of the river as a result of the plan.

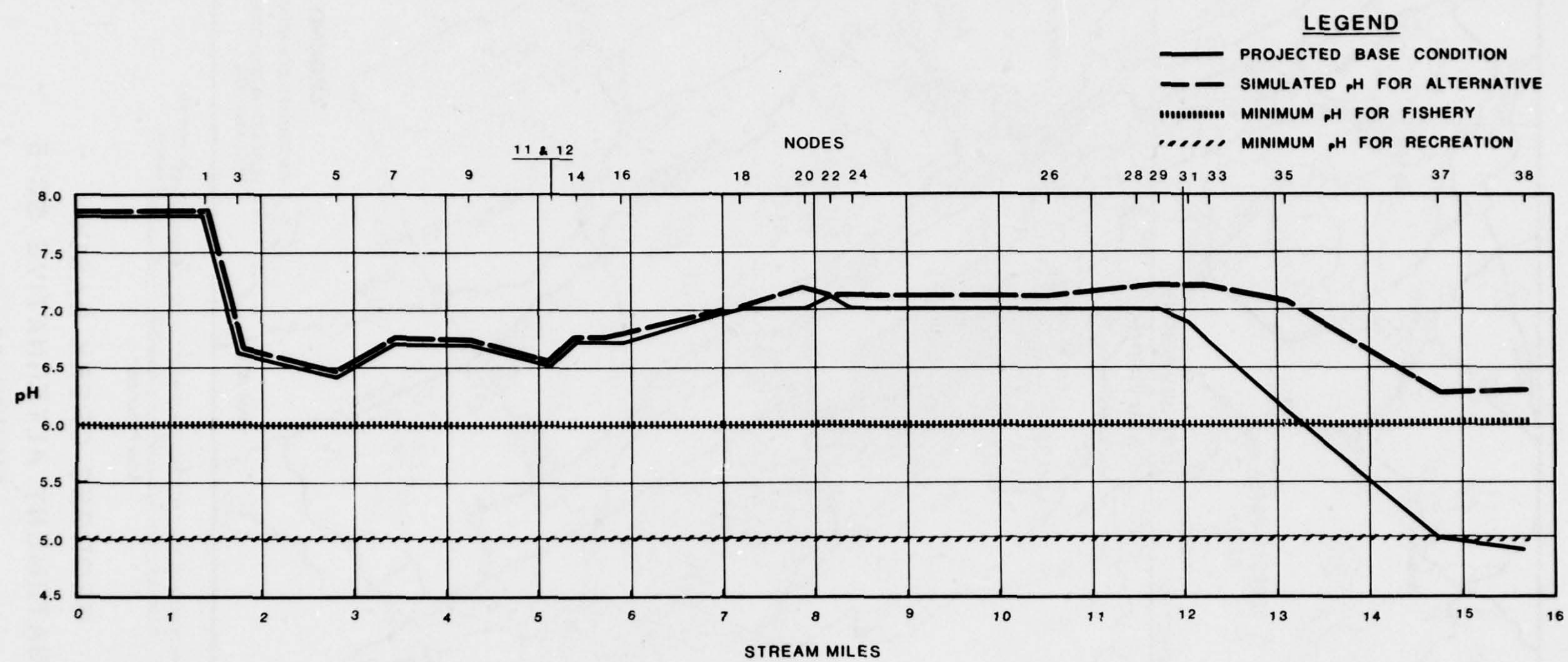
Land Use/Economics – Approximately 700 acres of new farmland will be created in the area north of Westernport. Urban development will intensify north of Westernport.

Ecological – Terrestrial habitat will be improved in the reclaimed areas. Water quality will not improve enough to significantly affect aquatic habitats.

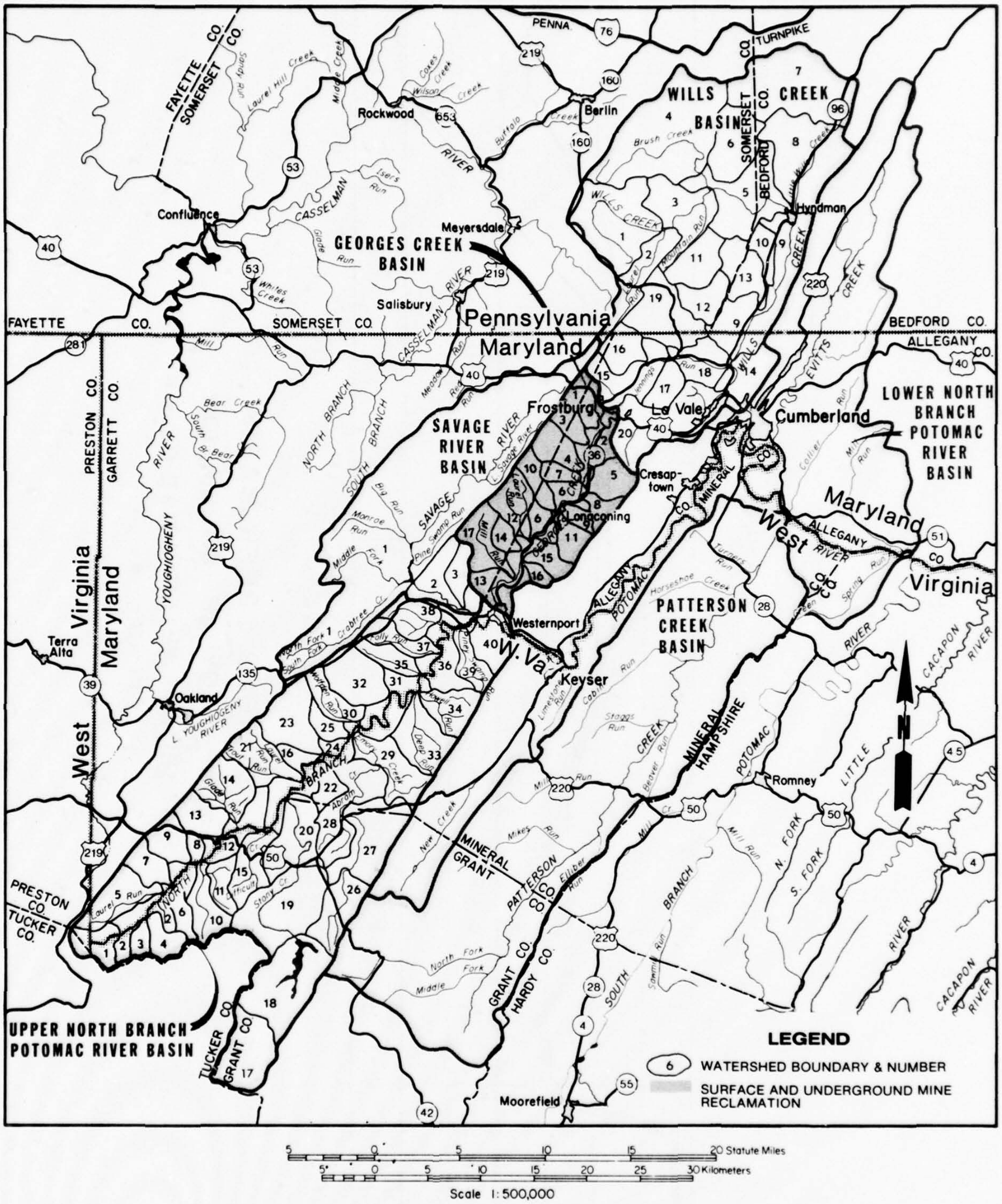
Benefits/Costs –

	Annual*
Reclamation Cost	$893,000
Plan Benefits	$562,000
Benefit Cost Ratio	0.63

*Over 30 year period discounted at 6 3/8 percent.



GEORGES CREEK BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE GC - 4
FIGURE 51



GEORGES CREEK BASIN
ABATEMENT ALTERNATIVE GC-5
FIGURE 52

Table 29
IMPACT SUMMARY
ABATEMENT ALTERNATIVE GC-5

Water Quality - Water quality will improve over the last four miles of Georges Creek to pH values above 7.0.

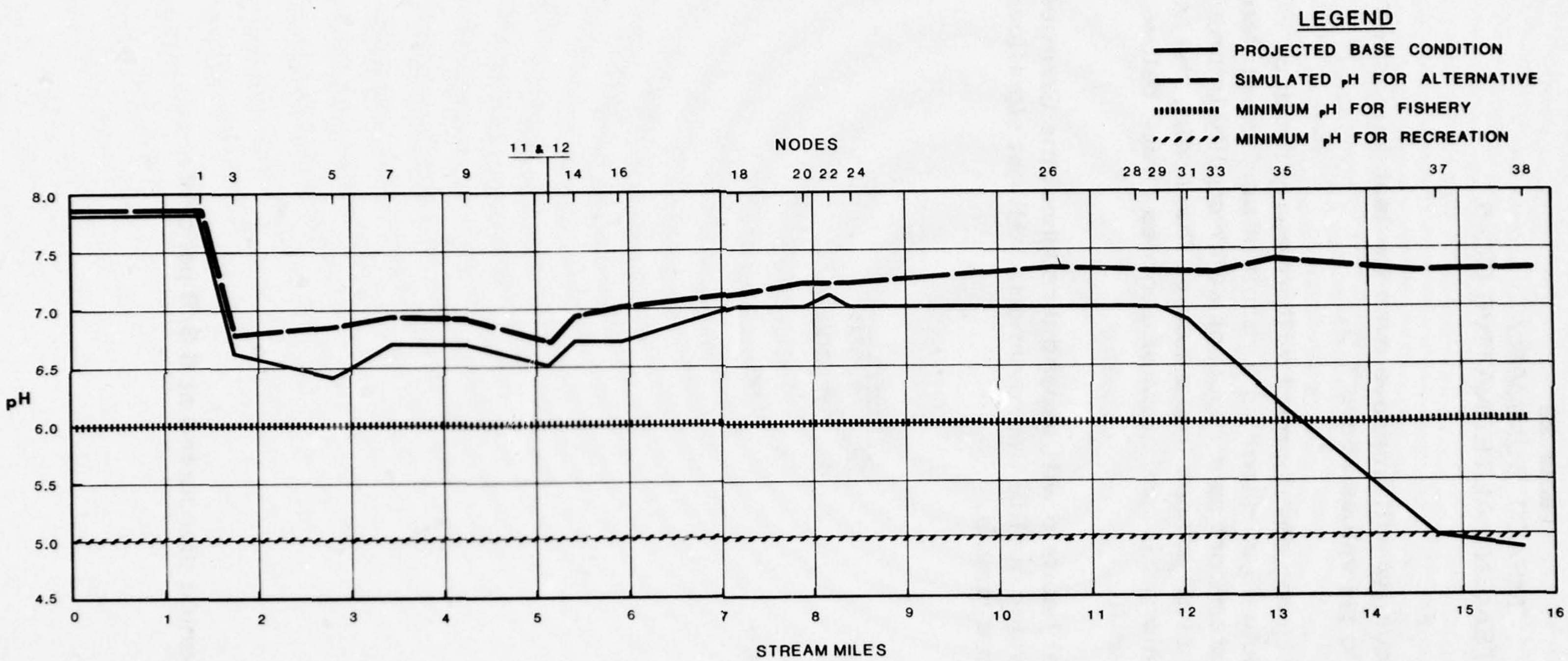
Land Use/Economics - Urban development will intensify south of Frostburg in Route 48 corridor as a result of surface reclamation and north of Westernport as a result of water quality improvements. Agricultural land will expand in the Laurel Run basin, the Mill Run basin, and along the mainstem of Georges Creek below Moscow, Maryland.

Ecological - Terrestrial habitats will expand throughout the Georges Creek basin. Water quality improvements will not significantly effect aquatic ecosystems.

Benefits/Costs -

	Annual*
Abatement Costs	$2,173,000
Plan Benefits	$ 787,000
Benefit Cost Ratio	0.36

*Over 30 year period discounted at 6 3/8 percent.

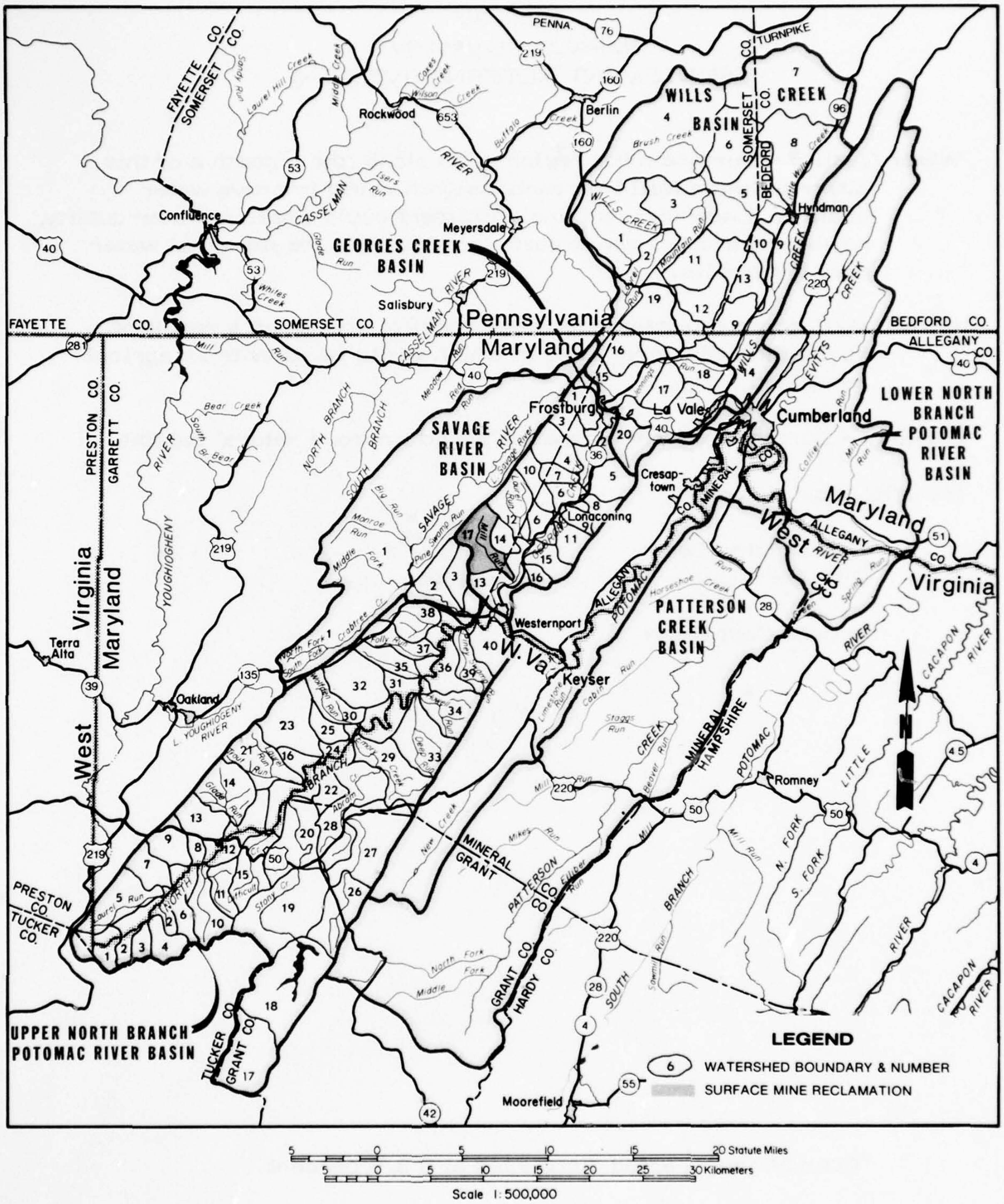


GEORGES CREEK BASIN

MEAN FLOW pH SIMULATION

ABATEMENT ALTERNATIVE GC - 5

FIGURE 53



GEORGES CREEK BASIN

ABATEMENT ALTERNATIVE GC-6

FIGURE 54

Table 30
IMPACT SUMMARY
ABATEMENT ALTERNATIVE GC-6

Water Quality - Surface mine reclamation alone (the objective of this alternative) on Mill Run cannot significantly improve water quality. Underground mine abatement could improve water quality, however the costs are excessive relative to the marginal water quality benefits.

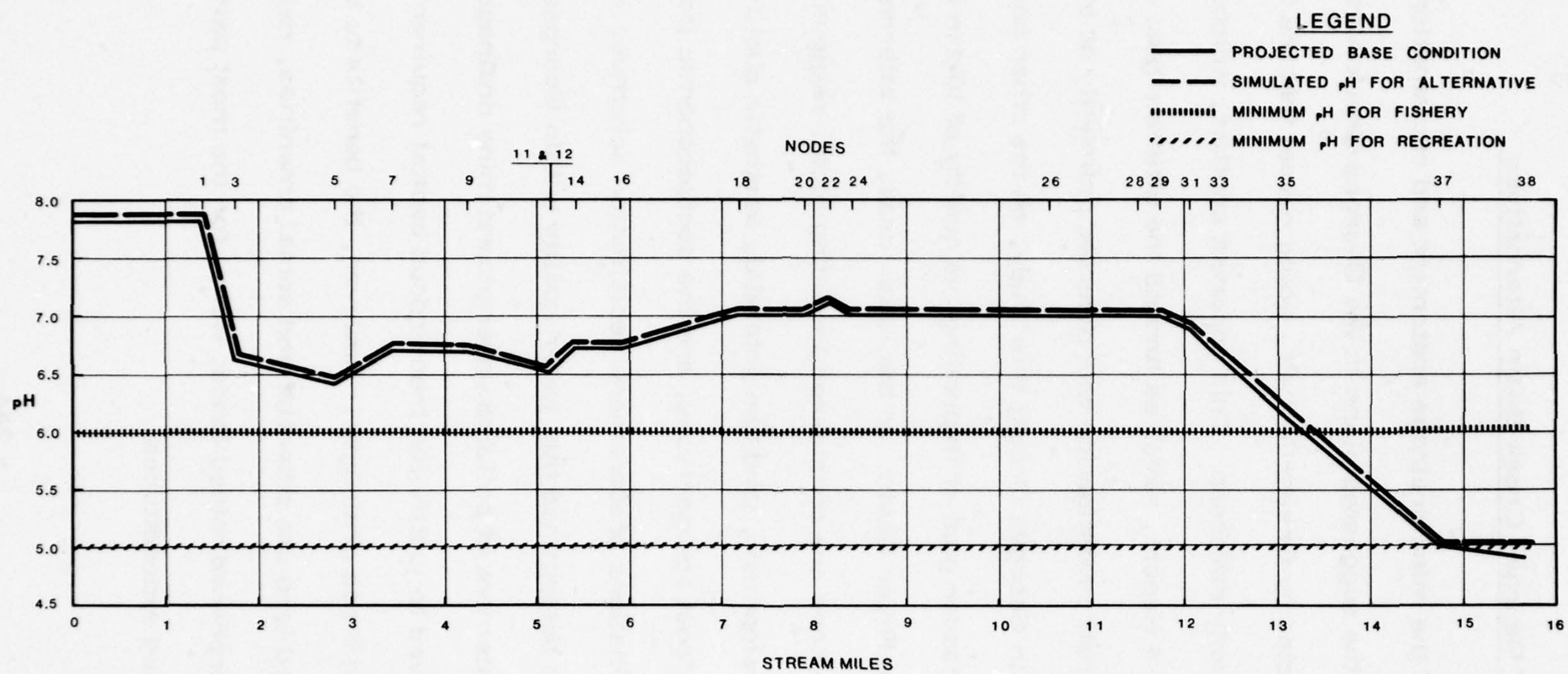
Land Use/Economics - Major land use benefits accrue as a result of reclaiming 646 acres, 523 of which would be useable as agricultural land.

Ecology - Surface mines reclamation would improve natural habitat.

Benefits/Costs -

	Annual*
Reclamation Cost	$76,000
Plan Benefits	$86,000
Benefit Cost Ratio	1.13

*Over 30 year period discounted at 6 3/8 percent.



GEORGES CREEK BASIN
MEAN FLOW pH SIMULATION
ABATEMENT ALTERNATIVE GC - 6
FIGURE 55

Summary of Georges Creek Basin Alternatives

Comparison of the mine drainage abatement and reclamation plans proposed above, with the suggested plans in the Georges Creek Mine Drainage Study conducted by Green-Gannett, would reveal that the two schemes are considerably different. This apparent conflict, which was addressed in the Task 4 Report, revolves around the ultimate goal of each study: the Green-Gannett investigation was directed primarily at improving water quality in Georges Creek; this study, on the other hand, is oriented toward the broader goal of improving the quality of life in the North Branch Potomac River Basin. In the latter case, the interrelationship of a number of factors are considered including local, regional, and national economic development, land use potential, aesthetic quality, water quality, benefit/cost comparisons, and the socioeconomic implications of various combinations of abatement/reclamation schemes. From this evaluation, it was determined that water quality within Georges Creek, resulting from the abatement of polluted underground mine drainage, was not sufficiently improved to justify the tremendous capital requirements involved in eliminating these drainages. However, the benefits to be derived from increased land use potential and social amenities, resulting from reclamation of orphaned mined lands, were, for the most part, in favor of these estimated expenditures.

A second factor affecting the compatibility of the Green-Gannett proposed plans with the scheme outlined in this report was the approach used in establishing abatement/reclamation recommendations. In the current study, the Georges Creek basin was divided into seventeen sub-watershed basins. Each sub-watershed was considered as a unit and priorities were established on this modular basis. Based on the finalized priorities, detailed watershed feasibility studies will be conducted (Phase II) on high priority watersheds to obtain the specific information required to develop reclamation/mine drainage abatement plans.

The Georges Creek study, on the other hand, was somewhat more comprehensive in that site specific information was assessed and individual reclamation/abatement schemes were recommended. However, due to the nature of this study, these recommendations were limited to three broad schemes, with each individual scheme involving particular sites throughout the entire Georges Creek basin. Priorities were not recommended on a site specific basis, as would be during Phase II of the current study. For this reason, it was necessary to reassess the Georges Creek basin in the current study to establish watershed priorities.

Fortunately, by combining these two assessments, site specific recommendations can now be determined for priority areas. This information can be effectively utilized to identify reclamation and abatement

TABLE 31

NATIONAL ECONOMIC DEVELOPMENT AND REGIONAL

ABATEMENT PLAN	ANNUAL COST	RECLAIMED ACRES	LAND ORIENTED BENEFITS (ANNUAL)								
			AGRICULTURE		TIMBER		HUNTING		AESTHETICS/ RECREATION		EMPLOYMENT
			ACRES	$ VALUE	ACRES	$ VALUE	ACRES	$ VALUE	ACRES	$ VALUE	$ VALUE
GC-1 Watersheds 1, 3, 5, 6	$ 153,000	851	40	4,000	119	595	159	2,798	174	2,140	46,000
GC-2 Watersheds 1 thru 12	650,000	2,140	314	31,400	1,531	7,655	1,845	32,472	1,531	18,831	195,000
GC-3 Watersheds 1 thru 13	448,000	2,858	425	42,500	2,138	10,690	2,563	45,108	2,138	26,297	135,000
GC-4 Watersheds 6, 14, 15, 16, 17, 13	893,000	2,189	686	68,600	1,503	7,515	2,066	36,362	1,503	18,487	268,000
GC-5 Watersheds 1 thru 17	2,173,000	3,932	900	90,000	2,637	13,185	3,514	61,846	2,637	32,435	652,000
GC-6 Watershed 17	76,000	646	523	52,300	123	615	523	9,205	123	1,513	23,000

TABLE 31

DEVELOPMENT ACCOUNT - GEORGES CREEK BASIN

LAND VALUE		TOTAL ANNUAL LAND BENEFITS	WATER ORIENTED BENEFITS (ANNUAL)					TOTAL ANNUAL WATER BENEFITS	TOTAL ANNUAL BENEFITS	BENEFIT / COST RATIO
			FISHING		NON-FISHING		WATER SUPPLY			
ACRES	$VALUE		MILES	$ VALUE	MILES	$ VALUE	$ VALUE			
295	14,750	$ 70,000	0	0	0	0	0	$ 0	$ 70,000	0.46
295	14,750	284,000	0	0	0	0	0	0	284,000	0.38
295	14,750	274,000	0	0	0	0	0	0	274,000	0.61
0	0	473,000	0	0	0	0	88,500	88,550	562,000	0.63
295	14,750	693,000	0	0	0	0	93,220	93,220	787,000	0.36
0	0	86,000	0	0	0	0	0	0	86,000	1.13

projects within the Georges Creek basin without the need for comprehensive Phase II efforts in this area.

Of the six alternate plans formulated for the Georges Creek basin, one attempted to maximize land improvement benefits (Alternative GC-6) while the remainder were targeted towards reducing acid loads from various watersheds. An interesting facet of the Georges Creek basin is that it is primarily the lower reaches which are responsible for the acid entering the North Branch Potomac at the confluence. Therefore, the plans which concentrate on reclamation in these areas are the most efficient in improving water entering the North Branch.

The summary account for the Georges Creek Basin Abatement Alternatives appears on pages 246 and 247.

Environmental Quality Account

None of the plans formulated for the Georges Creek Basin have any significant effect on the aquatic habitat of the basin. The major factor currently limiting the establishment of a healthy aquatic population is municipal and residential effluent, not acid pollution. The primary benefit accrued to any of the plans is land improvement.

TABLE 32

ENVIRONMENTAL QUALITY ACCOUNT
GEORGES CREEK BASIN

PLAN	ENVIRONMENTAL CONSIDERATIONS						
	AQUATIC HABITAT	AESTHETICS (WATER RELATED)	TERRESTRIAL HABITAT	AESTHETICS (LAND RELATED)	SOIL EROSION CONTROL	AIR QUALITY	TOTAL
GC-1	0	0	+1	+1	+1	+1	+4
GC-2	0	0	+2	+2	+2	+2	+8
GC-3	0	0	+3	+3	+3	+3	+12
GC-4	0	0	+2	+2	+2	+2	+8
GC-5	0	0	+3	+3	+4	+3	+13
GC-6	0	0	+1	+1	+1	+1	+4

Social Well-Being Account

This account evaluates elements of social well-being with respect to each plan. The income distribution category shown above is related directly to cost, since the greater the cost of the project, the more employment opportunities will be created. Given the high, persistent unemployment levels in the region, these plans will significantly improve the income position of lower income unemployed individuals. Thus, those alternatives with higher costs are rated with a greater number of pluses.

Health and safety are improved by three of the plans. Alternatives GC-4 and GC-5 both substantially improve the amount of agricultural land in the basin. They also improve water quality sufficiently to allow the use of the lower reaches of Georges Creek as a water supply for public and industrial uses. In Alternative GC-6, increases in agricultural land were sufficient to designate a plus for the health and safety category.

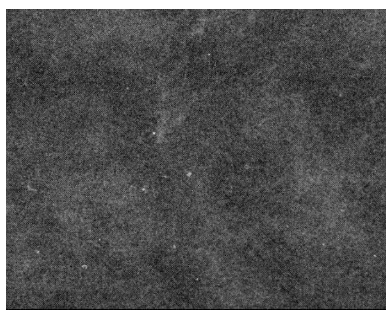
All the plans expand the land-oriented recreational opportunities in the basin. No plan significantly affects emergency preparedness.

The total column sums the number of pluses for each plan. Alternative GC-5 is superior to all other plans because of its higher employment benefits.

TABLE 33

SOCIAL WELL-BEING ACCOUNT
GEORGES CREEK BASIN

PLAN	SOCIAL WELL-BEING CONSIDERATIONS				
	INCOME DISTRIBUTION	HEALTH & SAFETY	EDUCATIONAL, CULTURAL & RECREATIONAL OPPORTUNITIES	EMERGENCY PREPAREDNESS	TOTAL
GC-1	+1	0	+1	0	+2
GC-2	+1	0	+1	0	+2
GC-3	+1	0	+1	0	+2
GC-4	+1	+2	+1	0	+4
GC-5	+2	+2	+1	0	+5
GC-6	0	+1	+1	0	+2



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ESTABLISHMENT OF PRIORITIES FOR PHASE II
WATERSHED STUDIES

Based on data generated during the first four tasks of this study, efforts were initiated in Task 5 to establish priorities for Phase II watershed reclamation and abatement activities. A two stage approach to priority establishment was utilized: 1) select the best abatement alternatives for Georges Creek and the North Branch Potomac River from among those developed in Task 4; and 2) establish some type of priority ranking that would encompass all of the watershed units within the North Branch Potomac Basin. These stages are discussed in the following pages.

SELECTION OF TOP ABATEMENT ALTERNATIVES

The first step — selection of the top ranking abatement alternatives — utilized data generated exclusively in Task 4. Two distinct approaches were utilized, and both led to the same conclusion for Georges Creek and North Branch Potomac River. One approach was based solely on water quality. It was felt that the only acceptable alternatives should be those in which downstream water quality was raised to a pre-determined acceptable standard. That standard was set at pH = 6.0, at the mouth of Georges Creek for the alternatives in that basin and at Bloomington Lake for the alternatives in the North Branch Potomac River. The alternatives

for each basin were originally defined in an attempt to achieve this objective at minimal cost while affecting the minimum number of watersheds; and when this objective was achieved, no further alternatives for either watershed — except for a "do-everything" alternative — were proposed. Thus, there are only two alternatives among those for each basin that achieve the pH = 6.0 standard — the minimum required effort and the "do-everything" alternative. Of these, the top ranked alternatives are those requiring the minimum effort — Abatement Alternative NBP-7A in the upper North Branch Potomac River Basin and Abatement Alternative GC-4 in the Georges Creek Basin.

Although the approach presented above for selecting the top ranking abatement alternatives is logical and easily justified, it is based solely on water quality. To more adequately utilize the land and reclamation oriented data generated during Task 4, as well as the water quality impacts, a second approach was also developed. This approach, which is illustrated in Tables 34 and 35, utilizes a point score on a series of parameters, with priority ranking subsequently based on a total point score for each alternative. Here, again, the supporting data was generated during Task 4. The parameters evaluated for each abatement alternative were:

- Annual Cost
- Reclaimed Acres
- Total Annual Land Benefits

TABLE 34

NORTH BRANCH POTOMAC RIVER BASIN
ABATEMENT ALTERNATIVE PRIORITY RANKING

ABATEMENT ALTERNATIVE	ANNUAL COST (1=LEAST)	RECLAIMED ACRES (1=MOST)	TOTAL ANNUAL LAND BENEFITS (1=MOST)	TOTAL ANNUAL WATER BENEFITS (1=MOST)	TOTAL ANNUAL BENEFITS (1=MOST)	BENEFIT/ COST RATIO (1=BEST)	ENVIRON-MENTAL QUALITY ACCOUNT (1=BEST)	SOCIAL WELL-BEING ACCOUNT (1=BEST)	POINT TOTALS
NBP-1 Watersheds 18, 19, 20	1	8	10	9	10	3	9	5	55
NBP-2 Watersheds 26, 27, 28, 29	2	7	8	6	8	2	8	4	45
NBP-3 Watershed 5	3	10	9	7	9	9	9	4	60
NBP-4 Watersheds 5, 32	4	9	7	8	6	10	7	4	55
NBP-5 Watersheds 5, 26, 27, 28, 29, 32	6	5	4	4	4	7	6	3	39
NBP-6 Watersheds 5, 18, 19, 20, 32	5	6	5	5	5	8	5	3	42
NBP-7 Watersheds 5, 18, 19, 20, 26, 27, 28, 29, 32	7	4	3	3	3	5	3	3	31
NBP-7A Watersheds 5, 18, 19, 20, 26, 27, 28, 29, 31, 32	8	3	2	2	2	4	2	2	25
NBP-8 Watersheds 2, 6, 8, 14, 19, 20, 21, 23, 26, 27, 29, SR-2, SR-3	1	2	6	9	7	1	4	4	34
NBP-9 All Watersheds	9	1	1	1	1	6	1	1	21

TABLE 35

GEORGES CREEK BASIN
ABATEMENT ALTERNATIVE PRIORITY RANKING

ABATEMENT ALTERNATIVE	ANNUAL COST (1=LEAST)	RECLAIMED ACRES (1=MOST)	TOTAL ANNUAL LAND BENEFITS (1=MOST)	TOTAL ANNUAL WATER BENEFITS (1=MOST)	TOTAL ANNUAL BENEFITS (1=MOST)	BENEFIT/ COST RATIO 1=BEST)	ENVIRON-MENTAL QUALITY ACCOUNT (1=BEST)	SOCIAL WELL-BEING ACCOUNT (1=BEST)	POINT TOTALS
GC-1 Watersheds 1, 3, 5, 6	2	5	6	3	6	4	4	3	33
GC-2 Watersheds 1 thru 12	4	4	3	3	3	6	3	3	29
GC-3 Watersheds 1 thru 13	3	2	4	3	4	3	2	3	24
GC-4 Watersheds 6, 13 thru 17	5	3	2	2	2	2	3	2	21
GC-5 Watersheds 1 thru 17	6	1	1	1	1	5	1	1	17
GC-6 Watersheds 17	1	6	5	3	5	1	4	3	28

* Total Annual Water Benefits
* Total Annual Benefits
* Benefit/Cost Ratio
* Environmental Quality Account
* Social Well-Being Account

These parameters were examined and simply ranked numerically for the ten North Branch Potomac Abatement Alternatives and the six Georges Creek Abatement Alternatives. A point total was then computed for each alternative, with the lowest point score signifying the best alternative. In both basins, the very best alternative was obviously the "do-everything" plan, but this does not represent the most efficient scheme available. Therefore the <u>second highest</u> point total was selected to represent the top ranking Abatement Alternative in each basin. According to the <u>unweighted</u> point scoring scheme, Abatement Alternatives NBP-7A and GC-4 again emerge as the best alternatives in the North Branch Potomac River and Georges Creek Basin, respectively.

Although the watersheds included in the two top ranking alternatives are obviously of high priority, the question arose as to whether abatement in the North Branch Potomac River Basin and in the Georges Creek Basin should, in fact, be considered of equal importance. The significance of downstream impacts of reclamation and abatement activities became a powerful factor here. The North Branch is seriously degraded throughout its length above Westernport, and any abatement activities within the upper

basin would be felt in the main stream. Of additional significance here is Bloomington Lake, which will be completed in a few years and will, at least initially, be degraded by acid mine drainage. Abatement activities upstream, particularly those recommended in Abatement Alternative NBP-7A, will have profound impact on the water quality of the lake and river. On the other hand, Georges Creek is <u>not</u> seriously degraded by mine drainage along most of its length, and the impact of abatement activities, even those recommended in the top ranking alternative, will not be major. In addition, Georges Creek flows into the North Branch just above the combined sewage treatment plant — Westvaco discharge, which raises the river to permanent alkalinity. Thus, abatement activities within Georges Creek will also have only minimal impact on the North Branch. Based upon this reasoning, it was determined that the Alternative NBP-7A watersheds should be of higher priority than the Alternative GC-4 watersheds. The method by which this was incorporated into the priority ranking activities will become evident in subsequent pages.

ESTABLISHMENT OF WATERSHED PRIORITIES

Once the top ranking abatement alternatives were delineated, efforts were initiated to develop a logical watershed priority ranking scheme. The objective here was a series of priority groups, each consisting of a

number of watersheds, any of which could be selected for Phase II activities. To achieve this objective, both water quality and land-oriented parameters were first ranked individually for each watershed. The individual rankings were then combined, and the resultant watershed "scores" were placed in a series of watershed priority groups.

Water quality priority ranking was conducted first and the rankings shown in Table 36 were developed. The following five priority classification system (based on information developed in Task 4) was employed:

Priority 1 - Watersheds in top ranking abatement alternatives - NBP-7A and GC-4.
Priority 2 - Remaining watersheds discharging greater than 500 lbs/day acid at their mouths.
Priority 3 - Remaining acid discharging watersheds.
Priority 4 - Watersheds with marginal or fluctuating water quality.
Priority 5 - Unpolluted watersheds.

Once each watershed was assigned one of the these five water quality priorities, a slight weighting modification was made to the scores. As previously mentioned, watersheds in the North Branch Potomac River have much more significant downstream impacts than do those in Savage River, Georges Creek, or Wills Creek. The only weighting factor utilized here relates to the relative location of the subject watershed. Those watersheds in which abatement and reclamation activities would have significant downstream impacts were considered most important. Since the only possible significant downstream impacts occur in the North

Branch Potomac River itself above the mouth of the Savage River, all remaining watersheds in the Upper North Branch, Savage River, Georges Creek, and Wills Creek, were penalized one point in the priority ratings. Thus, the weighted priorities (also in Table 36) are no longer representative of the priorities defined above.

The following land-oriented parameters were ranked numerically for each watershed not included in the top ranking abatement alternatives (NBP-7A and GC-4):

- Total Annual Costs
- Total Reclaimed Acres
- Total Annual Benefits
- Annual Benefit/Cost Ratio

Rankings for each watershed were totalled, and the resulting raw scores were lumped into a series of priority categories:

Priority 1 – All watersheds in abatement alternatives NBP-7A and GC-4.

Priority 2 – Watersheds having raw scores below 40, indicating a high reclamation and abatement desirability.

Priority 3 – Watersheds with raw scores between 40 and 50.

Priority 4 – Watersheds with raw scores between 50 and 60.

Priority 5 – Watersheds with raw scores above 60, indicating a low reclamation and abatement desirability.

No other weighting was employed in determining land-oriented watershed reclamation and abatement priorities. Land-oriented priority rankings are also summarized in Table 36.

TABLE 36

WATERSHED PRIORITY RANKING SCHEME SUMMARY

BASIN	WATERSHED NO.	DESCRIPTION	WATER QUALITY PRIORITY		LAND-ORIENTED PRIORITY	COMBINED SCORE	FINAL PRIORITY CATEGORY
			UNWEIGHTED	WEIGHTED			
Upper North Branch Potomac River	1	Main Stem	4	4	4	8	III
	2	Main Stem	4	4	4	8	III
	3	Deakin Run	3	3	5	8	III
	4	Elk Run	3	3	5	8	III
	5	Laurel Run	1	1	1	2	I
	6	Read Oak Creek	5	5	2	7	III
	7	Sand Run	4	4	5	9	IV
	8	Main Stem	5	5	4	9	IV
	9	Shields Run	5	5	5	10	IV
	10	Buffalo Creek	2	2	5	7	III
	11	Buffalo Creek	2	2	5	7	III
	12	Main Stem	5	5	4	9	IV
	13	Nydegger Run	5	5	3	8	III
	14	Glade Run	5	5	3	8	III
	15	Difficult Creek	2	2	4	6	II
	16	Main Stem	3	3	5	8	III
	17	Stony River	5	5	5	10	IV
	18	Stony River	1	1	1	2	I
	19	Stony River	1	1	1	2	I
	20	Stony River	1	1	1	2	I
	21	Trout Run	5	5	2	7	III
	22	Maple Run	5	5	5	10	IV
	23	Lostland Run	2	2	2	4	I*
	24	Main Stem	3	3	2	5	II
	25	Short Run	3	3	3	6	II
	26	Abram Creek	1	1	1	2	I
	27	Abram Creek	1	1	1	2	I
	28	Abram Creek	1	1	1	2	I
	29	Abram Creek	1	1	1	2	I
	30	Wolfden Run	5	5	4	9	IV
	31	Main Stem	1	1	1	2	I
	32	Threeforks Run	1	1	1	2	I
	33	Deep Run	5	5	2	7	III
	34	Howell Run	5	5	4	9	IV
	35	Elklick Run	2	2	3	5	II

*Watershed land primarily state-owned.

TABLE 36 (CONTINUED)

WATERSHED PRIORITY RANKING SCHEME SUMMARY

BASIN	WATERSHED NO.	DESCRIPTION	WATER QUALITY PRIORITY		LAND-ORIENTED PRIORITY	COMBINED SCORE	FINAL PRIORITY CATEGORY
			UNWEIGHTED	WEIGHTED			
Upper North Branch Potomac River	36	Main Stem	2	2	3	5	II
	37	Folly Run	5	5	4	9	IV
	38	Laurel Run	4	4	4	8	III
	39	Piney Swamp Run	2	2	4	6	II
	40	Main Stem	2	3	3	6	II
Savage River	1	Above Dam	*	*	*	*	V
	2	Below Dam	4	5	2	7	III
	3	Aaron Run	2	3	2	5	II
Georges Creek	1	Sand Spring Run	4	5	2	7	III
	2	Main Stem	3	4	3	7	III
	3	Winebrenner Run	3	4	4	8	III
	4	Woodland Creek	5	6	2	8	III
	5	Neff Run	3	4	4	8	III
	6	Main Stem	1	2	1	3	II
	7	Squirrel Neck Run	5	6	3	9	IV
	8	Elklick Run	5	6	4	10	IV
	9	Hill Run	3	4	4	8	III
	10	Koontz Run	5	6	3	9	IV
	11	Jackson Run	5	6	4	10	IV
	12	Laurel Run	3	4	2	6	II
	13	Main Stem	1	2	1	3	II
	14	Butcher Run	1	2	1	3	II
	15	Moores Run	1	2	1	3	II
	16	Unnamed	1	2	1	3	II
	17	Mill Run	1	2	1	3	II
Wills Creek	1	Main Stem	*	*	*	*	V
	2	Laurel Run	*	*	*	*	V
	3	Main Stem	*	*	*	*	V
	4	Brush Creek	*	*	*	*	V
	5	Main Stem	*	*	*	*	V
	6	Schaffers Run	*	*	*	*	V
	7	Little Wills Creek	*	*	*	*	V
	8	Little Wills Creek	*	*	*	*	V
	9	Main Stem	*	*	*	*	V
	10	Thompson Run	*	*	*	*	V

*No Pollutio[illegible] Mining.

TABLE 36 (CONTINUED)

WATERSHED PRIORITY RANKING SCHEME SUMMARY

BASIN	WATERSHED NO.	DESCRIPTION	WATER QUALITY PRIORITY		LAND-ORIENTED PRIORITY	COMBINED SCORE	FINAL PRIORITY CATEGORY
			UNWEIGHTED	WEIGHTED			
Wills Creek	11	Gladden Run	5	6	5	11	IV
	12	Rush Run	5	6	3	9	IV
	13	Gladden Run	*	*	*	*	V
	14	Main Stem	*	*	*	*	V
	15	Jennings Run	2	3	3	6	II
	16	Unnamed	2	3	3	6	II
	17	Unnamed	2	3	5	8	III
	18	Jennings Run	4	5	4	9	IV
	19	N. Br. Jennings Run	4	5	3	8	III
	20	Braddock	4	5	2	7	III
Patterson Creek Basin			*	*	*	*	V
Lower North Branch Potomac River Basin			*	*	*	*	V

*No Pollution or Mining.

At this point one previously unmentioned point was given serious consideration in weighting of the priority ranking system — state ownership of disturbed lands within study area watersheds. In Maryland, state ownership of land is mandatory before any reclamation and abatement activities can be attempted. Since time, efforts, and expenses involved in acquiring lands for such activities are considerable, watersheds in which much of the land is already state-owned could have a definite edge over others. Based on this premise, even a Maryland watershed with a less severe pollution load impact on the North Branch should be more

heavily weighted if it: 1) is a significant source of acid mine drainage; and 2) is primarily state-owned. Watershed 23 — Lostland Run — fits both of these criteria, and as a result was advanced from Priority II to Priority I in the rankings which follow.

Development of Final Watershed Priorities was a simple matter of totalling the water quality and land-oriented scores presented in the preceding tables, and grouping the results. The previously defined weighted water quality priority rankings and unweighted land-oriented priority rankings were added numerically, and the resultant scores were placed into one of the following five Final Priority Categories:

I - High Priority; Watersheds in Abatement Alternative NBP-7A plus Watershed 23 (Lostland Run) — all of which have a combined score of 2.

II - Watersheds having scores of 3 to 6; this includes those in Abatement Alternative GC-4.

III - Watersheds having scores of 7 or 8.

IV - Low Priority; watersheds having scores of 9 or greater.

V - No Priority; no pollution and no mining.

The combined water quality and land-oriented scores and the Final Watershed Priority Rankings appear in Tables 36 and 37, and are mapped in Figure 56.

Table 37

SUMMARY
FINAL WATERSHED PRIORITY RANKING

PRIORITY I

UNB-5	UNB-20	UNB-29
UNB-18	UNB-23	UNB-31
UNB-19	UNB-26	UNB-32
	UNB-27	
	UNB-28	

PRIORITY II

UNB-15	UNB-39	GC-14
UNB-24	UNB-40	GC-15
UNB-25	SR-3	GC-16
UNB-35	GC-6	GC-17
UNB-36	GC-12	WC-15
	GC-13	WC-16

PRIORITY III

UNB-1	UNB-14	GC-2
UNB-2	UNB-16	GC-3
UNB-3	UNB-21	GC-4
UNB-4	UNB-33	GC-5
UNB-6	UNB-38	GC-9
UNB-10	SR-2	WC-17
UNB-11	GC-1	WC-19
UNB-13		WC-20

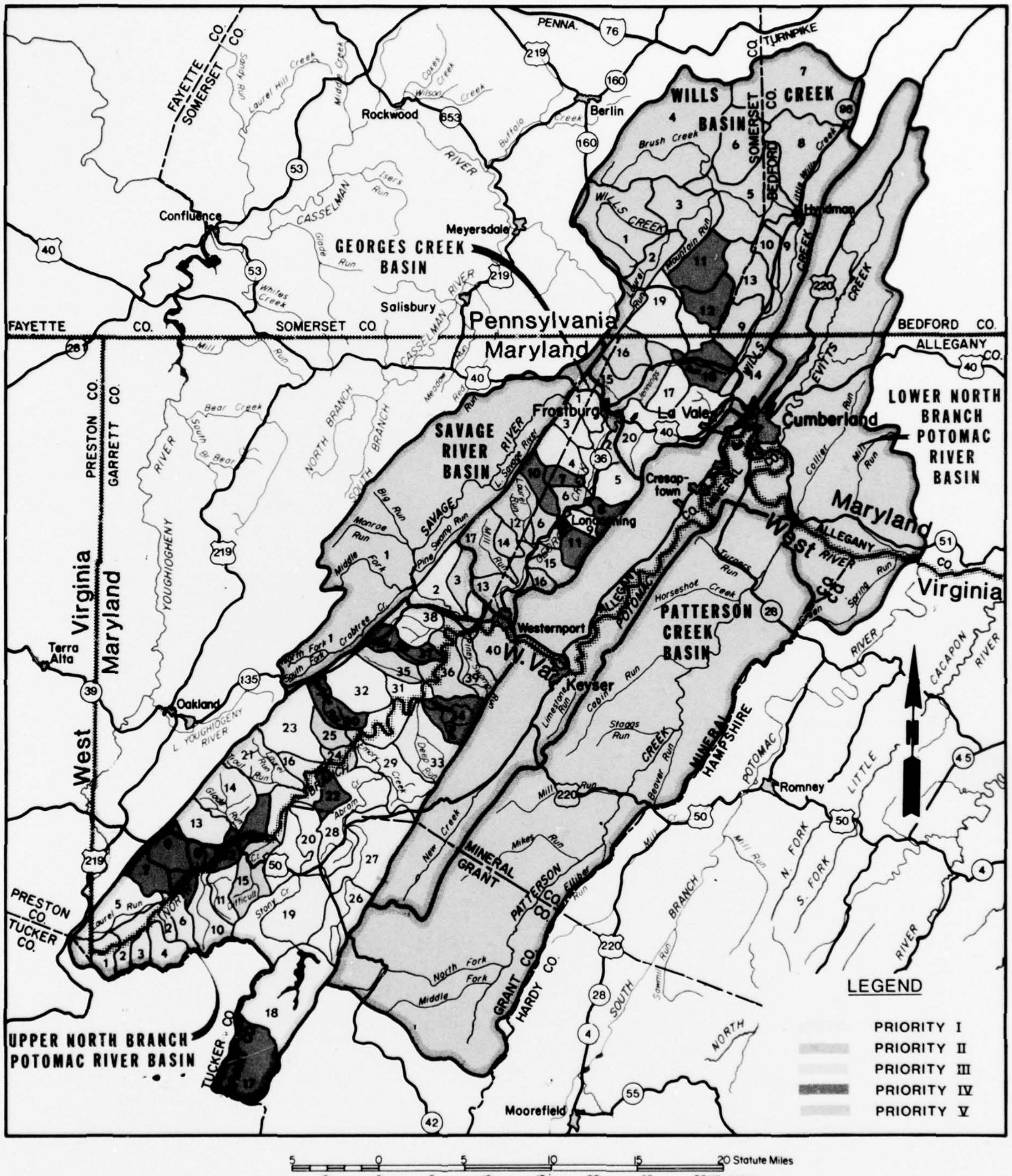
Table 37 (Continued)

PRIORITY IV

UNB-7	UNB-22	GC-10
UNB-8	UNB-30	GC-11
UNB-9	UNB-34	WC-11
UNB-12	UNB-37	WC-12
UNB-17	GC-7	WC-18
	GC-8	

PRIORITY V

SR-1	WC-5	WC-10
WC-1	WC-6	WC-13
WC-2	WC-7	WC-14
WC-3	WC-8	PC
WC-4	WC-9	LNB



FINAL WATERSHED PRIORITIES MAP

FIGURE 56

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BIBLIOGRAPHY

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BIBLIOGRAPHY

1. Allegany County Planning and Zoning Commission, Comprehensive Master Plan, Allegany County, Maryland, 1965.

2. Ambionics, Inc., Remote Sensing of Coal Mine Pollution in the Upper Potomac River Basin, May, 1974.

3. American Public Health Association, Standard Methods for the Examin- of Water and Wastewater, Thirteenth Edition, American Public Health Association, American Water Works Association and Water Pollution Control Federation, New York, 1971.

4. Appalachian Regional Commission, Acid Mine Drainage in Appalachia, 1969.

5. Appalachian Regional Commission, Impact of Mine Drainage on Recreation and Stream Ecology, 1969.

6. Appalachian Regional Commission, Impact of Mine Drainage Pollution on Industrial Water Users in Appalachia, March, 1969.

7. Appalachian Regional Commission, Impact of Mine Drainage Pollution on Location Decisions of Manufacturing Industry in Appalachia, 1969.

8. Baker, Michael Jr., Inc., Analysis of Pollution Control Costs, Appalachian Regional Commission, 1666 Connecticut Avenue, N.W., Washington, D.C., 1973.

9. Brodie, John, (Personal Communication) Timber Production on Reclaimed Lands, Maryland Forest Service, July, 1976.

10. Bureau of the Census, Census of Governments, 1972.

11. Bureau of the Census, Census of Housing, 1970.

12. Bureau of the Census, Census of Population, 1970.

13. Bureau of the Census, County Business Patterns, 1974.

14. Bureau of the Census, Current Population Estimates, April, 1976.

15. Clarkson, R.B., et al, Vascular Aquatic Plants in Acid Mine Water of the Monongahela River, 1971.

16. Creaser, C.W., Relative Importance of Hydrogen Ion, Temperature, Dissolved Oxygen and Carbon Dioxide Tension on Habital Selection by Brook Trout, "Ecology", 11:246, 1930.

17. Davis, R.M., Benthic Macroinvertebrate and Fish Population in Maryland Streams Influenced by Acid Mine Drainage, Natural Resources Institute, University of Maryland, Contribution No. 528, 1973.

18. Department of the Army, Baltimore District, Corps of Engineers, Bloomington Lake, Design Memorandum No. 14, Master Plan, July, 1973.

19. Department of the Army, Baltimore District, Corps of Engineers, Bloomington Lake, Design Memorandum No. 18, Environmental Analysis, April, 1972.

20. Department of the Army and House Document No. 87-469 (Original Published Document), Potomac River Review Report, North Branch Potomac River Above Cumberland, 1962.

21. Department of the Army and House Document No. 91-343 (Final Document), Potomac River Basin Report, Volume III and Volume IV, 1970.

22. Dinsmore, B.H., "The Effects of the Present Water Quality on the Occurrence and Distribution of Aquatic Life in Tom's Run, Farmington Township, Clarion County", 1967. Pennsylvania Department of Health and Department of Mines and Mineral Industries.

23. Doudaroff, P., and M. Katz, Critical Review of the Literature on the Toxicity of Industrial Wastes and Their Components to Fish, "Sewage and Industrial Wastes", 22(11):1432, 1950.

24. Evans, Robert J. and John R. Bitler, Coal Surface Mining Reclamation Costs - Appalachian and Midwestern Coal Supply Districts, Bureau of Mines Information Circular 8695, U. S. Bureau of Mines, 1975.

25. Garrett County Planning Commission, A Development Plan for Garrett County; May, 1974.

26. Georgia State University, Environmental Research Group, Economic Survey of Wildlife Recreation, March, 1974.

27. Green Associates, Inc. and Gannett Fleming Corddry and Carpenter, Inc. for Maryland Department of Natural Resources, Mine Drainage Abatement Investigations, Northwest Allegany County and Lower Georges Creek Complex, November, 1972.

28. Griffith, R.E., Letter to District Engineer Baltimore District Corps of Engineers, U. S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, July 15, 1974.

29. Homa, Ronald, (Personal Communication and Unpublished Data), Demand for Recreational Land in Western Maryland Region, Bureau of Outdoor Recreation, Northeast Regional Office, September, 1976.

30. Interstate Commission on the Potomac River Basin, Critical Areas in the Potomac River Basin - A Review of Water Pollution Control in 1975, December, 1976.

31. Interstate Commission on the Potomac River Basin, Economic Alternatives for the Upper Potomac River Basin and Their Relationship to Water Resources Management, July, 1976.

32. Interstate Commission on the Potomac River Basin, Legal Rights in Potomac Waters, Proceedings of a Conference at Harper's Ferry, West Virginia, September, 1976.

33. Interstate Commission on the Potomac River Basin, Potomac River Basin Water Quality Status and Trend Assessment, 1962 - 1973, March, 1975.

34. Interstate Commission on the Potomac River Basin, Potomac River Water Quality Network, Water Year 1972.

35. Interstate Commission on the Potomac River Basin, Proceedings of the 1974 Spring Meeting, June 5 - 6, 1974.

36. Interstate Commission on the Potomac River Basin, The Potomac - Water Quality Planning, Proceedings of Water Quality Planning Seminar, May 10, 1973.

37. Interstate Commission on the Potomac River Basin, Sediment, Proceedings of 1974 Fall Meeting on Sediment and Erosion Control in the States of the Potomac River Basin, November 7-8, 1974.

38. Irwin, Clint, (Personal Communication), Attendance at Savage River State Forest Fishing Areas, Maryland Forest Service, July, 1976.

39. Kmenta, Jan, Elements of Econometrics, 1971.

40. LaBuy, J.L., Biological Survey of the Upper Potomac River and Selected Tributaries, U. S. Department of the Interior, FWPCA, Data Report No. 4, 1966 - 1968.

41. Maryland Bureau of Air Quality, Maryland State Yearly Air Quality Data Reports, 1974.

42. Maryland Bureau of Mines, Annual Reports, 1952 through 1974.

43. Maryland Department of Economic and Community Development. Appalachian Maryland Development Plan, 1972 - 1973.

44. Maryland Department of Geology, Mines, and Water Resources, Geologic Map of Allegany County, 1956.

45. Maryland Department of Geology, Mines, and Water Resources, Bulletin No. 1, Summary of Records of Surface Waters of Maryland and the Potomac River Basin, 1892-1943, 1944.

46. Maryland Department of Geology, Mines, and Water Resources, Bulletin No. 9, Refractory Clays of the Maryland Coal Measures, 1950.

47. Maryland Department of Geology, Mines, and Water Resources, Bulletin No. 24, The Water Resources of Allegany and Washington Counties, 1962.

48. Maryland Department of State Planning, Geology, Aquifers, and Minerals Technical Report, Technical Series - Generalized Land Use Plan, January, 1974.

49. Maryland Department of Transportation, Maryland's National Freeway Approaches Completion, in "Appalachia", Volume 8, Number 6, June - July, 1975.

50. Maryland Department of Water Resources, Water Quality Division, Western Maryland Mine Drainage Survey - Volumes I, II, and III, 1962 to 1965.

51. Maryland Division of Economic Development, Community Economic Inventory, Allegany County, Maryland, June, 1972.

52. Maryland Division of Economic Development, Community Economic Inventory, Allegany County, Maryland, 1975.

53. Maryland Division of Economic Development, Community Economic Inventory, Garrett County, Maryland, June, 1972.

54. Maryland Division of Economic Development, Community Economic Inventory, Garrett County, Maryland, 1975.

55. Maryland Geological Survey, Coals of Maryland, 1905.

56. Maryland Geological Survey, Geologic Map of Garrett County, 1953.

57. Maryland Geological Survey, Report of Investigations No. 5, Chemical Quality Reconnaissance of Water of Maryland Streams, 1966.

58. Maryland Geological Survey, Report of Investigations No. 9, Chemical and Physical Character of Municipal Water Supplies in Maryland, 1969.

59. Maryland Geological Survey, Report of Investigations No. 16, Flow Characteristics of Maryland Streams.

60. Maryland Geological Survey, Report of Investigations No. 20, Hydrogeology of the Formation and Neutralization of Acid Waters Draining from Underground Coal Mines of Western Maryland, 1973.

61. Mays, Jim, (Personal Communication), Economics of Soil Erosion and Stream Sedimentation, Soil Conservation Service, Harrisburg, Pennsylvania, July, 1976.

62. McGraw-Hill Publications, Mining Informational Services, Keystone Coal Industry Manual, 1973.

63. Miernyk, W.H., The Upper Potomac River Basin — An Economic Overview, October, 1975.

64. MITRE Corporation - U. S. Army Corps of Engineers, An Assessment of the Impacts of Improved Water Quality in the North Branch Potomac River Basin, May, 1974.

65. Morton Hoffman and Associates, Second Homes in Maryland: Analyses and Projections of Location and Characteristics, 1970 - 1980, July, 1974.

66. Pacher, R., and W. Dunson, Anoxia and Sodium Loss Associated with the Death of Brook Trout at Low pH, "Comparative Biochem and Physics", 41:17, 1972.

67. Pennsylvania Department of Environmental Resources, Bureau of Topographic and Geologic Survey, Geology and Mineral Resources of Southern Somerset County, Pennsylvania, County Report 56A, 1965.

68. Pickard, Jerome, Per Capital Income Gap Between Appalachia and U. S. Diminishes in "Appalachia", Volume 8, Number 6, June - July, 1975.

69. Richer, W.E., Methods for Assessment of Fish Production in Fresh Waters, IBP Handbook No. 3, Blackwell Scientific Publications, Oxford, England, 1970.

70. Region 8 (W. Va.) Planning and Development Council, Annual Report and Overall Development Program, May, 1975.

71. Region 8 (W. Va.) Planning and Development Council, Annual Report and Overall Development Program Update, May, 1975.

72. Ross, R.D. and G.E. Lewis, Stream Survey of District II, West Virginia, Department of Natural Resources, Wildlife Resources Division, Charleston, W. Va., 1969.

73. Schmidt, J. William and Raymond M. Haas, West Virginia Travel and Tourism Study, 1965.

74. Shrikly, R.W., Letter to District Engineer Baltimore District Corps of Engineer, U. S. Department of Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, February 2, 1974.

75. Skelly and Loy, Coal Mine Drainage in the Susquehanna River Basin, Susquehanna River Basin Commission, 1973.

76. Skelly and Loy, Coal Resource Evaluation of the Georges Creek Coal Company's Mineral Holdings Within and Adjoining the Savage River State Forest, Maryland Department of General Services, 1973.

77. Skelly and Loy, Economic Engineering Analysis of U. S. Surface Coal Mines and Effective Land Reclamation, U. S. Bureau of Mines, 1975.

78. Skelly and Loy, Economic Evaluation of Small Surface Coal Mines in Appalachia, U. S. Environmental Protection Agency, Washington, D.C., September, 1976.

79. Skelly and Loy, Effluent Limitations Guidelines for the Coal Mining Industry, U. S. Environmental Protection Agency, Washington, D.C., 1975.

80. Skelly and Loy, Mine Drainage Pollution Watershed Survey Cherry Creek and Casselman River Watersheds, Maryland Department of Natural Resources, May, 1973.

81. Skelly and Loy, Processes, Procedures, and Methods to Control Pollution from Mining Activities, EPA-430/9-73-011, Washington: U. S. Environmental Protection Agency, October, 1973.

82. Skelly and Loy, Up-Dip Versus Down-Dip Mining - An Evaluation, EPA-670/2-75-047, Cincinnati, Ohio: U. S. Environmental Protection Agency, June, 1975.

83. Stalling, James L., Resources of the Upper South Branch Valley, June, 1967.

84. Stanford Research Institute for U. S. Army Engineer Institute for Water Resources, Handbook of Forecasting Techniques, December, 1975.

85. State of Maryland, Unpublished Field Stream Survey Data, Department of Natural Resources, Water Resources Administration, Annapolis, Maryland, 1974.

86. State of West Virginia, Unpublished Field Stream Survey Data, Department of Natural Resources, Wildlife Resources Division, Operations Center, Elkins, W. Va., 1970 - 1973.

87. Tennant, D.L., "Instream Flow Regimens for Fish, Wildlife, Recreation and Related Environmental Resources", Fisheries, Vol. 1, No. 4, July - August, 1976.

88. Tri-County Council for Western Maryland, Appalachian Maryland Development Plan, July, 1975.

89. United States Army Corps of Engineers, Institute for Water Resources, Handbook of Forecasting Techniques, December, 1975.

90. United States Army Corps of Engineers, North Branch of the Potomac River, Maryland and West Virginia, Volume IV, Appendix H, U. S. Government Printing Office, Washington, D.C., 1962.

91. United States Army Corps of Engineers, pH Measurements at North Branch Potomac River Bridges in Vicinity Bloomington Dam Site, 1975.

92. United States Army Corps of Engineers, Potomac River Basin Report, Volume IV, Appendix J, Fish and Wildlife, U. S. Government Printing Office, Washington, D.C., 1970.

93. United States Department of Commerce, National Oceanic and Atmospheric Administration, Climates of the States, Volume 1 - Eastern States Plus Puerto Rico and the United States Virgin Islands, 1974.

94. United States Department of Commerce, Area Economic Projections 1990, Social and Economic Statistics Administration, (Undated).

95. United States Department of Interior, Bureau of Mines, Information Circular, The Reserve Base of U. S. Coals by Sulfur Content, Part 1 - The Eastern States, 1975.

96. United States Department of Interior, Bureau of Mines, Information Circular 8531, Strippable Reserves of Bituminous Coal and Lignite in the United States, 1971.

97. United States Department of Interior, Bureau of Mines, Information Circular 8655. The Reserve Base of Bituminous Coal and Anthracite for Underground Mining in the Eastern United States, 1974.

98. United States Department of Interior, Bureau of Mines, Microfilm mapping of abandoned mines within the Potomac River Basin.

99. United States Department of Interior, Bureau of Mines, Technical Paper No. 725, Investigations of Lower Coal Beds in Georges Creek and North Part of Upper Potomac Basins, Allegany and Garrett Counties, Maryland, 1949.

100. United States Department of Interior, Federal Water Pollution Control Administration, Stream Pollution by Coal Mine Drainage in Appalachia, 1969.

101. United States Department of Interior, Fish and Wildlife Service, National Survey of Hunting and Fishing, 1970.

102. United States Geological Survey, Water Resources Data for Maryland and Delaware, Part 2 - Water Quality Records, 1972 and 1973 Editions.

103. United States Geological Survey, Water Resources Data for West Virginia, 1972 and 1973 Editions.
Part 1. Surface Water Records
Part 2. Water Quality Records
Part 3. Ground Water Records

104. United States Geological Survey, Water Supply Paper No. 2035, Geohydrologic Reconnaissance of the Upper Potomac River Basin, 1975.

105. United States Geological Survey, West Virginia Geological and Economic Survey, and West Virginia Department of Natural Resources Division of Water Resources, Basic Data Report No. 3, Records of Wells, Springs, and Streams in the Potomac River Basin, West Virginia, 1974.

106. United States Water Resources Council, OBERS Projections, April, 1974.
Volume 1, Concepts, Methodology and Summary Data
Volume 3, Water Resources Regions and Sub-areas
Volume 7, Non-SMSA Portions of Water Resources Sub-areas

107. Water Information Center, The Water Encyclopedia, 1970.

108. Water Resource Engineers, Inc., Water Quality Data Collection and Simulation Study for North Branch Potomac River Basin Acid Mine Drainage Study, October, 1973.

109. Water Resources Research Center, Blacksburg, Va./Walker, William R., Economics of Air and Water Pollution, October, 1969.

110. Weber, C.I., Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents, Program Element 1BA027, National Environmental Research Center, Office of Research and Development, U.S. Environmental Protection Agency.

111. West Virginia Department of Natural Resources, Division of Water Resources, West Virginia Acid Mine Drainage Study in the North Branch Potomac River Basin, July, 1974.

112. West Virginia Geological and Economic Survey, Geology of the Keyser Quadrangle, 1963.

113. West Virginia Geological and Economic Survey, Probable Original Minable Extent of the Bituminous Coal Seams in West Virginia, 1970.

114. West Virginia Geological and Economic Survey, Report of Investigations No. 10, The Geology of the Pittsburgh Coal, 1971.

115. West Virginia Geological Survey, County Reports - Mineral and Grant Counties, 1924.

116. Westvaco, Luke Mill Report, 1974.

117. Westvaco, Water Quality Data for North Branch Potomac, Industrial Influent and Effluent, 1975.

118. Woronecki, David, (Personal Communication), In-Stream Flow Requirements for Managed Trout Fisheries in Maryland, Maryland Fisheries Administration, September, 1976.

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